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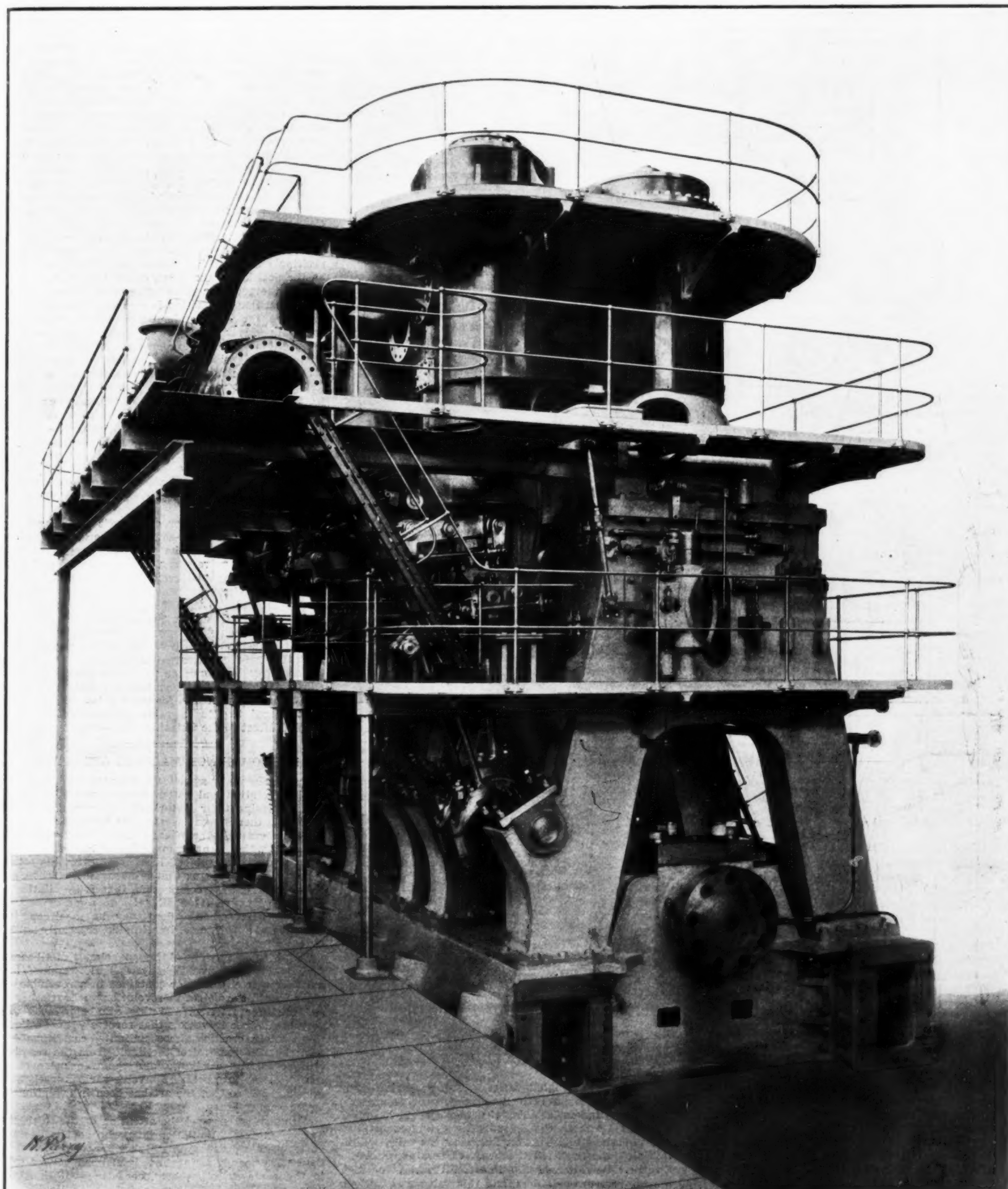
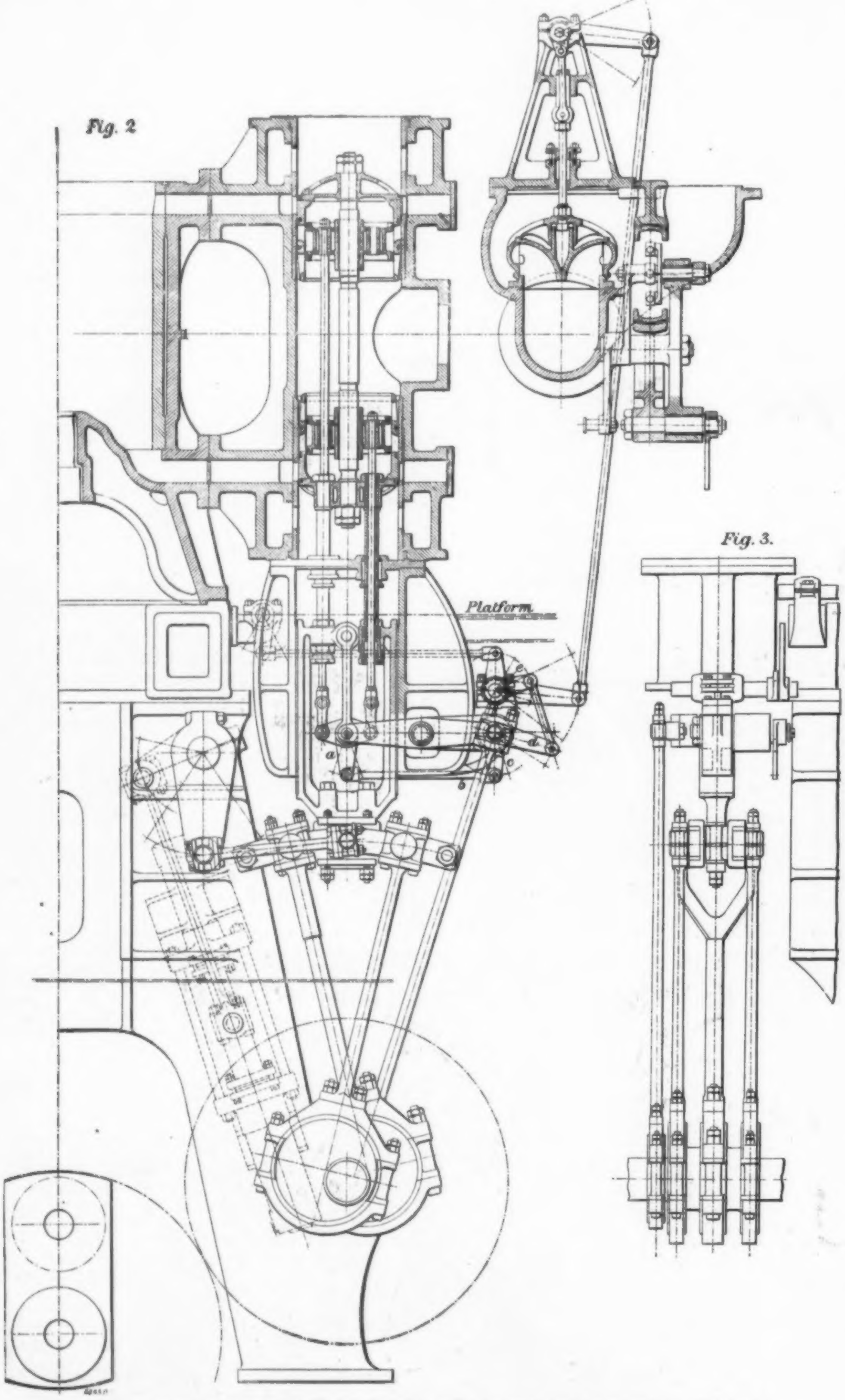


AN 18,000 HORSE-POWER ENGINE, THE LARGEST ROLLING-MILL ENGINE EVER BUILT.

18,000-HORSE-POWER ROLLING-MILL ENGINES.

We illustrate a vertical rolling-mill engine capable of indicating 18,000 horse-power, recently constructed by Messrs. Richardsons, Westgarth & Co., Limited, Middlesbrough. The engine is designed to take steam at 200 pounds per square inch, and to run at 200 revolutions per minute, and weighs 500 tons. The engine is intended to drive the heaviest class of rolls, and to be very economical in steam. The general character of the engine is capitally shown in the engraving, which conveys an excellent idea of its massive proportions. The three cylinders are all 45 inches in diameter with a 52-inch stroke. The engine can either be worked as a compound engine, having one high-pressure (the middle one) and two low-pressure cylinders; or high-pressure steam can be admitted direct to all three, the change being made instantly, by means of a patent valve operated by hydraulic pressure. The engine bed-plate is 4 feet deep, the metal being 3 inches thick, while the crank-shaft, which is in three interchangeable pieces, is 22 inches in diameter at the bearings. The cranks are arranged at 120 deg. The bearings are lined with white metal and are unusually long. Nickel steel has been used for the piston and connecting rods, and other working parts.

Until quite recent years few rolling-mill managers paid much attention to the matter of steam economy, and in one such works we remember a steam pipe was carried for a quarter of a mile through an underground drain which frequently ran full of water. Of late years, however, economy in all points has had to be studied at steel works, and as a consequence condensing engines have gradually come into favor, and flywheels have also been dispensed with, as while they helped the engine in an emergency, they made the engine much less easy to handle, and thus led to a waste of steam. With a view to a further reduction in steam consumption, it was highly desirable to compound these engines, but there were certain difficulties to be overcome in view of the extreme suddenness with which the load on the engine varies. The governing gear must act direct on both the high-pressure and low-pressure cylinders, as otherwise there would be quite sufficient steam in the low-pressure cylinders to give rise to serious racing as an ingot left the rolls. With this view the Cockerill Company, of Seraing, placed a throttle-valve between the intermediate receiver and the low-pressure cylinders, and this valve was worked simultaneously with the high-pressure throttle-valve. The same object is attained in the engines under discussion by the adoption of the Rottmann patent valve gear, which is shown in detail in Figs. 2 and 3. With this gear each cylinder is fitted with cut-off valves working inside the main valves, and these expansion valves are shifted to cut off earlier simultaneously with the closing down of the throttle-valve on the main steam supply. As shown in Fig. 2, the latter valve is of the Cornish double-beat type. A link connects it with a way-bar running along the whole front of the engine; and links and bell-cranks leading from this control the positions of the expansion valves.



DETAILS OF VALVE-GEAR OF 18,000-INDICATED-HORSE-POWER ENGINE.

As represented in Fig. 2, the valves are all of the piston type, with the expansion valves working inside the main valves. The main valves are in two parts, connected together by a central rod, as shown. The lower of the two portions is connected by two hollow rods with a head sliding in guides, this head being driven direct by the link. This link is driven by eccentrics in the usual way, but, as shown in Fig. 3, there are two forward eccentrics and a single reverse eccentric—an arrangement which gives straight leads for the eccentric rods. These eccentrics, it will further be noted, are mounted on a side shaft driven by gearing from the crank-shaft, and not mounted direct on the latter. The expansion valve-rods pass through the hollow rods driving the main valve, as shown. They terminate in links connecting them to opposite ends of a lever, the center point of which is mounted on a link pivoted on the sliding-head of the main valve, and is also further controlled by being coupled to the inside end of a lever, the outer end of which is connected to the top of the rod for the expansion eccentric. The only possible motion of the cut-off valves, it will be seen, will be due to a rocking on its bearing of the lever to which their rods are coupled. This motion is procured by means of the lever and links marked *a*, *b*, *c*, *d*, *e* in the diagram. The position of the point, *c*, depends on the position of the throttle-valve, to which it is connected, as already explained, and on nothing else. Hence, as the sliding-head of the main valve moves up, and as the end of the expansion-rod eccentric also moves, the lever, *a*, is rocked to and fro, the mean position about which it rocks being dependent solely on the position of the point, *c*, and this in its turn on that of the governor valve. The lever, *a*, being rocked in this fashion, its motion is communicated to the cut-off valves, the position about which they oscillate over the main valves being thus ultimately dependent on the position of the governor gear. Engines fitted with similar valve-gear have been in use for some time in continental steel works, and have shown a great saving in the expenditure of steam. Thus at the Differdingen works the blooming mills were originally driven by two non-condensing engines, each having two cylinders 51¼ inches in diameter with a 55-inch stroke. One of these engines was replaced by a compound condensing engine fitted with the Rottmann gear, and the saving of steam in working a bloom down to 5½ inches square from 19¾ inches square was not less than 916 pounds per bloom, the daily production being 350 blooms.

An emergency governor of Crowe's centrifugal type is fitted on end of crank-shaft. It operates an hydraulic valve, which closes the emergency stop-valve when required. This valve can also be controlled and re-set from the starting platform, and the starting gear is fitted on a platform (not shown on the drawings) opposite to the mill, so that the attendant controlling the engines is directly opposite to the rolls.

These engines, which appear to be of an exceptionally strong design and heavy construction, and carefully worked out in detail, are one of two sets which the builders have in hand for the Cargo Fleet Iron Company, Limited, of Middlesbrough, for their new works. The engine illustrated is for the cogging mill, to which it is geared two to one; the second engine will be coupled direct to the finishing mill.—Engineering.

PHENOMENA OF MACHINE OPERATION.*

Among the many agencies and means that contribute to the evolution and better performance of machines and determine their endurance and economy of construction, there is one, sometimes ignored and in all cases underrated—the phenomena of their operation; that part which is not computable or learned by rules.

To present the subject in a practical way, I have chosen the only means that seem available when considering things not computable, that is by citation or observed facts, and I shall refer to some typical examples. First among these may be mentioned the evolution of apparatus to impel fluids, especially liquids, by centrifugal force.

This is seemingly one of the most simple of all means for creating pressure. A body of liquid, confined in a fixed circular chamber, or contained in a revoluble circular vessel, can be set in revolution without other resistance than friction, and this can be reduced to a very low degree in vessels that revolve with the liquid they contain, creating almost unlimited centrifugal tension; but the removal of the liquid from the vessel or chamber, or its discharge, and the translation of its rotary energy into pressure involve various mechanical impediments, so that the art has been in evolution for half a century past.

This process engaged the attention of the celebrated French engineer, Emil Bourdon, who constructed machines that worked up to high-water pressure—more than 1,000 pounds per inch, it is claimed. Some work in the same direction has been done within a few years past here in California, both with liquids and with elastic fluids, but with what particular results I am not able to say. I mention the method as one phase

* A paper read by Mr. John Richards before the Technical Society of the Pacific Coast.

in the evolution of centrifugal apparatus that may in future have some importance.

During the latter half of the past century, which covers practically the development of the common forms of centrifugal pumps, in which the fluid is set in revolution in a fixed chamber or casing, we have had a maze of computations by eminent scientific men bearing upon the construction and operation of such machines; but so far as I am aware, no clear or correct explanation of the phenomena of their operation, or of the varied conditions of their use.

Such computations as we have were naturally based upon certain assumed premises derived from obvious hydraulic laws, and, to some extent, from experiments; but these latter have not been of a kind to disclose what we call the principle or mode of action, including the whole passage of liquid through the machines.

The main resistances that qualify effect were sought out and shortened into formulas, which are in the main correct. Arrangements and proportions were based upon such formulated data, and fifty years have since passed with progress, it must be admitted; but, as I maintain, without providing a clear concept and treatment of what has been called the phenomena of operation. Strange to say, the impediment to such concept and treatment was confined almost wholly to the simple matter of returning the water, after its rotation, to a state of rest or service flow without a loss of the kinetic energy required to set the water in revolution.

That there was a good deal of mystery in this matter is sufficiently proved by the fact that a good share of the literature relating to such pumps has been devoted to the shape of the impelling vanes—a thing which modern practice shows to be of no importance, and almost a negligible matter in constructive design. The function of such vanes is to set the water in revolution, and is but little more, except as to a slight modification of frictional resistance. The body of confined water in revolution is the thing to be considered. The vanes, except as to the function named, are merely a portion of the mass in revolution, moving at a rate relatively which renders their shape and curves a matter of little importance.

It was, or should have been, obvious from the beginning that the only considerable loss of energy took place in the zone between the impellers and the collecting or discharge chambers; but it required, as before stated, about half a century to complete this discovery, or, rather, to devise apparatus that would adapt itself to this fact, and a manner of operating accommodated thereto.

The most successful attempt at preserving or utilizing the kinetic energy of the water's revolution was made a few years ago by Messrs. Sulzer Brothers, of Switzerland, who introduced separating vanes in the dispersion zone of centrifugal pumps, to divide the water into distinct divergent streams and to preserve it from agitation until its energy was translated into pressure.

To accomplish this, the dispersion passages had to begin with an area that would collectively vent a particular volume of water at the velocity required to balance the head or resistance. Such construction, when the castings and internal surfaces were true and tolerably smooth, increased the efficiency of such pumps, for the higher pressures, about 10 per cent or more, compared to those without a dispersion zone or when the water is discharged from the impeller directly into a collecting chamber; but, at the same time, it set up impediments and limitations of a very formidable kind.

The castings are difficult to make; the acute points of the dispersion vanes wear away; but, most of all, the pumps have to be driven at an invariable speed and to deliver a specific volume of water in order to gain this higher efficiency. There is also a very considerable increase in dimensions and in cost of construction, and it remains to be seen whether a satisfactory efficiency cannot be attained without encountering these impediments.

We are in no position to know the value of divided water passages in the dispersion zones of such pumps until the cause of losses there is understood. A mass of water, moving at a high velocity, is easily disturbed and broken up into devious currents and courses, especially when the water is moving in a circular path, and it is easy to conceive that rough-cast surfaces and imperfect shape of the dischargeway produced the principal loss in an open discharge zone. Computation furnishes no clue to this matter.

The future will, no doubt, determine this, not suddenly, or as a discovery, perhaps, but by a careful study of the construction and adaptation of such pumps to the theoretical and also the practical conditions of design.

To make a theoretical centrifugal pump from computed data is quite a simple matter. A diagram, to cover or include the water passages through a pump, with a cross-section as the volume and inversely as the velocity, the length of the diagram representing the acceleration and retardation of flow, will disclose a design theoretically correct, and would only require that such a diagram be surrounded by a confining chamber of sufficient strength.

In practice, however, such a scheme would fail. Every pump would become a special machine for a specific volume and head; contraction of the water passages would prevent the passage of solids, except those of small size; the disturbance by the roughness of interior surfaces and divergence of course would interrupt and modify the velocity of flow; the machines could not be cheaply produced by the implements of organized manufacture; they would fail to meet the diversities of use, and the cost would far exceed the commercial standards that now prevail.

The conditions of practical use demand that pumps be made, within certain limits, for both high and low pressures, or with a considerable range of adaptation to different pressures; they have to be employed for various liquids, pure and impure, viscous and corrosive, and to pass solids of various kinds, including sand and gravel. They must endure abrasive scour in their water passages and exposure of their journal bearings, and they must be provided against unequal pressure or lateral thrust on the impellers. Interior surfaces, where the velocity is great, should be in true contour and finished smooth, with other features which could be named and which lie wholly outside of what we may call a compound or theoretical construction.

These are the circumstances such as cause long periods of evolution, require extensive observance of the phenomena and conditions of operation, and have to be learned tentatively, by inference, observation, and experiment.

I have reverted at some length to centrifugal pumping, but the like circumstances apply to nearly all fluid machines which, as a class, have received the highest possible scientific treatment.

For another example, turbine water-wheels were made the subject of research by eminent French engineers, who, previous to the middle of the past century, commissioned and aided by their government, laid down laws and scientific rules to govern the construction of these important machines. It was, no doubt, the most thorough and successful attempt of the kind ever made, and produced the three types of turbine waterwheels known as the Fourneyron or outward flow, the Jonval or parallel flow, and the partial turbines or impulse wheels of Girard.

About 1850 the subject was taken up in this country by two American engineers, Boyden and Francis, who constructed, at Lowell, Mass., what have remained, to the present time, the finest examples of Fourneyron turbines on this continent. Mr. Emil Geyelin, a French engineer, came a little later to Philadelphia and introduced the Jonval type of turbines. The Girard type or partial turbines have not been successfully exploited in this country, if we except the wheels lately erected at Niagara Falls.

Here was a complete mathematical development of water turbines, carried out to a skilled construction and to operate at the greatest efficiency. The subject of the water turbine seemed ended, and the writer, who was then engaged in that bygone occupation called "millwrighting," assumed and claimed that this art at least had culminated. And so it had, in so far as efficiency was concerned; but there was another phase to be dealt with in the operating conditions.

The French turbines were refined machines, exact, expensive, and adapted for pure water. Our streams are mostly in flat lands, fluctuating and turbid. Gravel, driftwood, and other kinds of debris would not pass through the fine issues of the new turbines, and American mechanics began, in an experimental way, "whittling" out new models. In the French wheels the running, finished, and expensive elements were outside, and occupied the extreme diameter, while the rough and inexpensive fixed elements were placed internally, and were of relatively small diameter. This resulted in expensive construction and a slow rate of revolution, requiring strong and expensive gearing for transmission.

So accustomed were engineers to associate centrifugal effect with turbines, that radial or outward flow seemed an essential condition, when, in fact, it had little or nothing to do with the case. This was found out by experiment, and should have been evident from the beginning.

The American mechanics, after many years of "whittling" out models, succeeded in turning the wheels "inside out," or inverted them, so to speak, making the internal or smaller elements the running part, so that the water flowed inward toward the center, then changed its course 90 deg. downward in helical passage for escape. This was done entirely without scientific aid, in some cases even controverting scientific rules, and the result is the centripetal or inward flow turbine, the standard water wheel of this country, of which a single firm has made more than 10,000, and the wheels have even found their way back to France. Their efficiency is fully equal to, or even greater than, that of the older types, and the cost of the wheels is about one-half as great. This evolution has required about sixty years, and present practice rests mainly upon observed phenomena, and upon the operating conditions, rather than upon computed data. There was not even a draftsman in the works where were made the wheels that gained the highest award at the careful trials conducted at the Centennial Exposition in 1876.

This whittling method, as it has been called, was certainly slow and unnecessary, but was followed by shrewd mechanics in a roundabout way at great and unnecessary expense in money and time. At least, this is the way the matter seems to us now; but we are undoubtedly proceeding in like manner in the case of many other less intricate machines, as posterity may point out.

In respect to the Girard type or impulse wheels, Weisbach and others had contemporaneously, or earlier, investigated the laws that govern the effect of impinging fluids, and such laws were carefully observed in the development of partial turbines in Europe, where such wheels are now the standard type for the open or impulse class; but on this coast, mainly by reason of very high heads or pressures and the accurate work required in wheels of this kind, there commenced, about twenty-five years ago, a modification suggested by the peculiar operating conditions, producing a new class, known as the "tangential" type.

The development of this was, to a great extent, another case of "whittling" out models, and the old experience had to be gone over again. Notwithstanding that a good deal of scientific data relating to such waterwheels was furnished at the beginning by Prof. F. G. Hesse, of the University of California, the phenomena of operation continued to be observed, and from various clues modifications were made, down to 1900, when it was discovered that the double buckets could be passed into and out of the stream by once dividing it. Other final features in the design of such wheels were noted also. They have since taken on the dress and finish of proper design and workmanship.

In the case of elastic fluids, impulse motors or steam turbines have been more than a century in evolution, notwithstanding that more than 400 separate patents have been granted in Great Britain alone for inventions pertaining to these machines, some of them a century ago and many of them fifty years ago. Mr. Parsons, an eminent English engineer, who has been prominent in this work during later years, is no doubt one of the greatest living adepts in the science of thermodynamics, and, as is claimed, he has forecast with much accuracy the development of his turbine schemes as they progressed from 48 pounds down to 11 pounds of steam for each horse-power-hour, but it is also claimed that he has expended half a million dollars in experiments. He has probably expended more than this.

If inquiry were made, Mr. Parsons would probably admit that not one-fourth of his data came from computed sources, and that the observed phenomena of operation and adaptation have comprised the other three-fourths.

I might mention Lenoir's gas engine, the first of the internal combustion class. I examined an old engine in 1870, the first successful one, and I strongly suspect that, aside from the operating phenomena, this machine has furnished suggestions for nearly all improvements since, except perhaps the graduated combustion in the Drayton and Diesel types, yet in evolution, owing to impediments that arise in construction.

A wider and more important example of evolution in operating phenomena is furnished by piston steam engines. I do not mean the thermodynamic development of these, which is the greater part, furnished mainly by scientific deduction and experiment, but to the mechanical evolution of their operating parts, which had to keep pace with the thermal problems.

The "elimination of the speed factor," as our worthy president calls it, not only in the rotative, but also in the reciprocating, parts of such engines is a wonderful example of experimental development.

Down to twenty-five years ago it was a common object, in steam-engine design, to reduce surface and velocity in bearings, partly to avoid friction, and partly because reduction of weight and space were also incentives, but the operating phenomena of machine bearings was a mystery in so far as any scientific rules were available.

Forty years after the publication of Gen. Morin's experiments, which established a generally accepted law of friction, we find that alignment and pressure were considered subordinate when compared with surface in bearings.

Alignment, or the fit of bearing surfaces, especially in the case of cranks, is yet a mystery, if considered in a practical way. The most careful computations respecting the flexure of shafts, frames, crank disks, and pins, fail to disclose the operating phenomena. One has only to observe the center of an overhung crank or disk, even of the strongest proportions, to see that it describes a visible ellipse when under heavy strain and for reasons not explainable by computation. French makers of steam engines so dread this phenomenon that, I believe, none of them employ overhung cranks.

Similar obscure operating conditions exist in various other parts of steam engines, and proportions are, beyond question, based more upon observed operating phenomena than upon computed dimensions.

Bearings that operate under steam—slide valves, for example—were scraped to a perfect fit; cylinders were bored out with a smooth, glistening surface, under a belief that such fitting was theoretically correct; but, by accident mainly, it was found that the bearing surfaces performed much better when they were not smooth and in perfect contact. A film of interposed water or oil produced the uniform fit.

In crushing hard material, such as quartz, with metallic surfaces, it was naturally inferred that the metal opposed to the stone should be as hard as possible; but, for reasons not easy to explain, soft metal endures longest. Cornish rollers are now covered with rings or tires of soft, fibrous iron. The sand blast discloses a like phenomenon. It is easier to bore a hole through a file with the sand jet than through a thin sheet of copper. An emery wheel will rapidly cut away tempered steel, but not soft iron. It is a problem of friability, no doubt, but it is not fully explained.

The whole field of mechanics is full of unexplained phenomena and mysteries, such as the temper of steel, the fatigue of metals, their crystallization under rhythmic concussion, the inherent strains in molded steel, the surge and reaction of moving liquids under high pressure.

New Explosive Substances.—The Italian chemist Angeli proposes the employment of hydroxamic acids and their salts as explosive compounds, such as the salts oxalhydroxamic acid forms with calcium, strontium, barium, and other metals, which explode under the action of percussion, of heat, or of flame. These

salts may be employed alone or mixed with nitrates, chlorates, perchlorates, and aromatic nitro-compounds, replacing mercury fulminate in the preparation of percussion caps, and priming of any kind for the explosion of dynamite, gun cotton, explosive gelatines, picric acid, etc.

PROTECTED GALVANOMETER.*

By EMILE GUARINI.

THE two accompanying figures represent the Siemens & Halske protected galvanometer of the Du Bois & Rubens type. One shows the mechanism and the other the complete apparatus.

This instrument, the reverse of apparatus with revolving coil, and like galvanometers of the old type, is provided with a stationary winding and a movable magnetic arrangement. The magnetic protection is obtained through a triple jacketing of cast steel and is so perfect that the influence of magnetic disturbances is reduced to a nine one-hundredth of what it would be in a non-protected instrument of the same type. The third jacket of magnetic protection, consisting of a cast-steel cylinder with bottom and cover, is omitted in Fig. 1, but is seen in Fig. 2, which represents the same galvanometer with spherical jacket, but complete. The sensitiveness of the galvanometer with spherical jacket is expressed as follows for one degree with a distance of 1,000 degrees and a ten seconds' duration of oscillation:

Resistance of Coil.	Heavy Suspension.	Light Suspension.
2 × 5 ohms.	4 × 10—9	4 × 10—10
2 × 500 ohms.	8 × 10—10	8 × 10—11
2 × 2,000 ohms.	2 × 10—10	2 × 10—11

FIG. 1.—SIEMENS & HALSKE'S PROTECTED GALVANOMETER. DETAILS OF MECHANISM.

According to Ayrton and Mather's definition of sensitiveness, we obtain the following values:

Suspension.	Sensitiveness in the Current.
Heavy	80
Light	800

When the light suspension is employed, the sensitiveness is ten times greater than that obtained with the heavy suspension. Nevertheless, the conditions to be fulfilled concerning the establishment of the galvanometer then become multiplied to a very great degree. In coils of high resistance, shunts with spring-jack contacts are joined to the galvanometer. The windings of such shunts are of copper so as to do away with corrections of temperature.

CONTEMPORARY ELECTRICAL SCIENCE.†

VARIATION OF CAPACITY WITH TEMPERATURE.—E. M. Terry has used the alternate-current galvanometer for the purpose of determining the variation of a capacity with temperature. The difficulty in manipulation lies in the fact that a closed coil of wire suspended in an alternating magnetic field takes up a position of great stability in the position in which its axis is at right angles to the field. Stroud and Oates overcame this by placing upon the coil another closed coil at right angles. Since, however, a lagging current in the coil makes it take a position with its axis at right angles to the field, the author made it practically astatic by properly adjusting the conductivity and capacity across the coil. Two capacities were compared by the bridge method, using the alternate-current galvanometer, with a drop of 220 volts across the bridge. The ratio of the capacities could be determined to 0.01 per cent, that being the limit to which the resistances could be depended upon. However, by keeping the resistances practically constant and shunting across a small part of one of them, a change in one of the capacities of the order of one part in 100,000 could be easily detected. The temperature coefficient of each part of a sub-divided condenser was obtained working between 16 deg. and 33 deg. It was found to be negative, and to vary between 0.01 and 0.03 per cent per degree for the different parts.—E. M. Terry, Physical Review, June, 1905.

WIRELESS TELE-MECHANICAL ACTION.—E. Branly describes an apparatus by means of which several different mechanical actions can be produced at will at a distant station without the assistance of anyone stationed there. Thus the impact of electro-magnetic waves may be made to start a motor, light a lamp or produce an explosion. The choice or succession of these various actions is regulated by a rotating commutator at the distant station. It has as many disks as there are actions to control. For those actions, each disk would be provided with a sector of larger radius covering 90 deg. While this sector is in contact with a brush, the apparatus reacts upon a spark from the transmitting station and produces the action desired. The operator at the transmitting station is informed of the position of the disks by a constant succession of signals from the receiving station, actuated by the rotating commutator. By introducing a reversing gear, the actions may be started or stopped at will. The

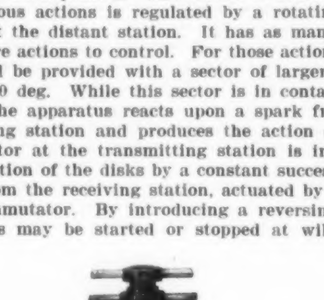
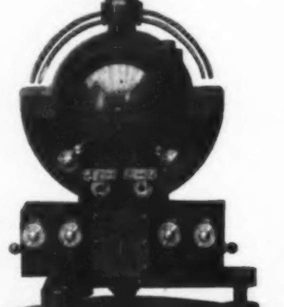


FIG. 2.—SIEMENS & HALSKE'S PROTECTED GALVANOMETER. COMPLETE APPARATUS.



THE SPHERICAL JACKET.

commutator itself may be started or stopped by electro-magnetic waves. The author describes a method by which the operator at the transmitting station can assure himself that the apparatus at the receiving station is working satisfactorily. He has also devised an apparatus for protecting the receiving station from adventitious waves.—E. Branly, Comptes Rendus, March 20 and June 26, 1905.

ALUMINOTHERMIC PROCESS.—Binary compounds of aluminium may be obtained by igniting a mixture of aluminium powder and a metalloid such as sulphur or phosphorus. A. Colani has carried this process further, and has obtained binary compounds of other metals by reducing a metallic oxide with aluminium in presence of a metalloid. In a magnesia-lined crucible he places a well-stirred and thoroughly dried mixture of the oxide and the aluminium powder in theoretical proportions, with the metalloid in excess if it is volatile. It is then ignited with a magnesium cartridge. The reaction is often violent. The metalloid may be replaced by its oxide, and reduced by the aluminium together with the metallic oxide. This is especially convenient in the case of arsenic or antimony, if the heat disengaged by the action of aluminium upon the metallic oxide is insufficient to melt the mass. In the case of silicon and boron, the preliminary preparation of these elements becomes unnecessary. Also, it is possible to add mixtures like $3CuO + 2Al$ or $3SnO_2 + 4Al$, and thus to attain temperatures which rival the electric furnace. The difficulty encountered is that of removing the metallic aluminium remaining uncombined. The author gives a number of examples, such as arsenides and phosphides of iron and uranium, and silicides and borides of copper and iron.—A. Colani, Comptes Rendus, June 3, 1905.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

† Compiled by E. E. Fournier d'Albe in the Electrician.

[Continued from SUPPLEMENT No. 1555, page 24920.]

IRON AND STEEL HULL STEAM VESSELS OF THE UNITED STATES.*

By J. H. MORRISON, Author of "History of American Steam Navigation."

II. 1840-1860. ATLANTIC COAST.

A PERIOD had now arrived when it seems that the best results of the early experiments in marine engineering made in this country were ready for application to the iron hull, brought about by the experience obtained by the use of a few sidewheel iron steamboats, and the service of the iron-hull screw propeller "Robert F. Stockton." The conditions were, however, favorable in many ways for the change, from the steamboat owners' as well as the builders' point of view. The operation of our sidewheel boats under a steam pressure of 30 pounds and over, and the general application of the cut-off, made it more favorable to use the short stroke and higher piston speed of the propeller engine. There was no period when there were more numerous experiments made, and greater fallacies exploded regarding the application of a propelling agent to a steam vessel, than from 1840 to 1850. It was in the early days of this period that Robert L. Stevens designed the steam battery of iron for the United States navy, that was to be driven by twin screws; and who was the pioneer in the development of the iron war vessel. John Ericsson was also a very prominent marine engineer during this time, being largely engaged in the application of the screw propeller to merchant vessels.

In 1842 there was built by Stackhouse & Tomlinson, of Pittsburg, Pa., under the supervision of Charles W. Copeland, who was at the time naval engineer of the United States navy, associated with Samuel Hart, naval constructor United States navy, the naval steamer "Michigan." This vessel was put together at Pittsburg, taken down, and shipped in sections *via* the Beaver canal to Erie, Pa., on Lake Erie, where it was re-erected and launched for service on Lake Erie in 1843. Her dimensions are 162 feet 6 inches between perpendiculars, 27 feet beam and 12 feet 5 inches depth of hold. She is a side-wheel vessel, and driven by a pair of inclined condensing engines, each having a cylinder of 36 inches diameter and 8 feet stroke. Some of the scantlings of the vessel are as follows: Frames of T iron, 4½ inches by 4 inches; distance center to center, 24 inches; reverse bars, 4 inches by 2½ inches; floors, 6½ inches by 4½ inches; keel plates, ⅝ inch thick; side plating, 5-16 inch thick; stem and stern posts, 6½ by 1½ inches; sheer strake, ⅜ inch thick, and the iron plating carried up to the rail. Deck beams of both the main and berth decks of T iron. Five heavy box keelsons were run the whole length of the vessel. The iron for the whole of this vessel was rolled by H. S. Spang & Son, of Pine Creek, Pa. This vessel is still on the register of the Navy Department.

The iron mills of Great Britain were rolling much heavier plate iron at this time than the American rolling mills, for in 1839 the largest plates rolled were by the Colebrookdale Iron Company for Fawcett, Preston & Co., of London, England, of two plates, each measuring 10 feet 7 inches long, 5 feet 1 inch wide, and 7-16 inch thick. They were intended for bottom plates of a steam boiler. The steamship "Great Britain," built in 1841, had keel plates ¾ inch thick in middle of keel and 1 inch at ends. All the underbody plates were ⅝ inch to ½ inch, and sheer strake was ⅝ inch, and double riveted throughout. The angle iron frames were 6 inches by 3½ inches by ½ inch at bottom of vessel, and 7-16 inch thick at the top, having centers of 14 inches. There were ten iron keelsons, of which the center ones were 3 feet 3 inches deep.

In 1842 Moses Starr & Sons, of Philadelphia, Pa., built a small sidewheel boat of 80 feet by 12 feet by 4½ feet deep, of iron, having two high-pressure horizontal engines, and named "Appaquernick." She ran for a short time on the Delaware River, when she was sold and sent to South America.

During the same year there was built by Hogg & Delamater, of the Phenix Foundry at New York city, at the foot of Jane Street, for the Delaware and Raritan Canal Company, from designs furnished by John Ericsson, four iron propeller canal steamboats, each 96 feet long, 24 feet beam, and 7 feet depth of hold. They were named "Anthracite," "Vulcan," "Black Diamond," and "Ironsides." They were each fitted with an engine of the grasshopper type of 18 inches by 24 inches stroke of piston, and driven by twin screws of 5 feet 10 inches diameter. These were the first twin-screw steam vessels in this country. The frames were principally of T iron, and very heavy for the size of the vessel. The iron plating was mainly of American manufacture, though there was some English iron used on the bottoms of two of the vessels. These vessels remained in service until 1850, when the bottom plates of all the vessels were found to be so badly corroded in places, both internally and externally, that they were covered with wood planking. The iron hulls were protected from oxidation with red lead and oil.

Hogg & Delamater, who succeeded James Cunningham at the Phenix Foundry, later in 1842 constructed for H. R. Worthington, of Brooklyn, N. Y., an iron-hull steam canalboat that was named "Pioneer." Her dimensions were 73 feet 10 inches long, 14 feet beam, by 5 feet 7 inches deep. She was placed on a line between New York and Canada *via* the Champlain Canal, but was subsequently in use on the Dismal Swamp Canal in Virginia.

In 1843 and 1844 the United States government had constructed for the Revenue Marine Service, eight iron-hull steamers. On February 28, 1843, contracts

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

were signed for the building of the "Tyler," the "Jefferson," and the "Legàre." On April 2 of the same year, the "Dallas" and the "McLane"; on April 18, the "Spencer"; and on December 4, 1844, the "Polk" and the "Walker."

The "Tyler" was built at Pittsburg, Pa., by Charles Knapp, and fitted with Hunter's submerged wheel. She was launched as the "George M. Bibb" April 10, 1845, and was subsequently transferred to the Coast Survey January 9, 1847. She was 161 feet long, 22 feet beam, and 11 feet 10 inches depth of hold. Tonnage, 409 tons.

The "Jefferson" was also built at Pittsburg, Pa., by the same builder as constructed the "Tyler." This vessel was 160 feet long, 24 feet beam, having 9 feet 6 inches draft of water. Her engine was of the horizontal high-pressure type, 36 inches diameter of cylinder and 32 inches stroke of piston, and driving an Ericsson propeller. This vessel, after being put together at the works of the builder, was taken apart and shipped to Oswego on Lake Ontario, where it was re-erected, launched, and finished for service. She was subsequently brought to the Atlantic coast with the "Dallas" by the way of the St. Lawrence River and rapids.

At the time it was contemplated to bring these two vessels from the lakes, there had not been any vessel which had passed down the rapids of the St. Lawrence River drawing over 7 feet, and as these vessels were of a draft of over 9 feet, it became necessary to obtain reliable information as to the greatest draft of water for a vessel to pass down the rapids with safety, before any attempt was made to take them through this dangerous and treacherous part of the river. All inquiries on the matter failed to elicit any definite information. Desiring to get the vessels through to the coast, the Revenue Marine officers were thrown on their own resources, and adopted a plan of their own to obtain the desired information. They procured a large scow, and upon each side placed and fastened two scantlings so that they projected below the bottom of the scow, with the idea that in floating down the rapids, if they should strike any obstruction, they would be torn off, and thus indicate that the shoalest part of the rapids was not as deep as the length of the scantlings below the surface of the water. The scow was started on its first trip for a 7½ feet draft, and the scantlings or gages were intact on the scow's arrival at the foot of the rapids. It was sent on several more trips down the rapids, each time increasing the length of the gages till there was found to be sufficient water to float these vessels with safety. The scow was sent down till the gages were torn off in passing down the rapids, and the depth of water was then estimated to be about 12 feet in the shoalest spot in the channel.

The "Legàre" was built at New York by H. R. Dunham & Co., marine engine builders. Her dimensions were 160 feet long, 24 feet beam, 11 feet deep, and drew 9 feet of water. This vessel was designed by John Ericsson, engineer, of New York city, and was fitted with a screw propeller. The power was derived from one horizontal high-pressure engine, the cylinder being 36 inches diameter and 32 inches stroke. After a few years' service for the United States government, she was sold to private parties, who placed her in the merchant service, and changed her name to "Commerce."

The "Dallas" was built by Stillman, Allen & Co., the Novelty Iron Works, of New York city. She was of the same dimensions as the "Tyler." The vessel was put up at New York, taken down, and erected again at Buffalo, N. Y., and launched April 4, 1846. She was fitted with the ordinary radial wheel. This vessel was brought to the coast about 1850, and on March 4, 1851, was sold at New York to E. Campbell.

The "McLane" was contracted for by Cyrus Alger, of Boston, Mass., but was built by Jabez Coney at South Boston. She was originally constructed with Hunter's submerged wheel, but was changed to a sidewheel vessel before being put in commission, without alteration of her engines. Her dimensions were 161 feet long, 22 feet beam, and 11 feet 10 inches depth of hold, with a mean draft of water of 9 feet 6 inches. Her engines were two horizontal non-condensing engines, having cylinders each 24 inches diameter with 36 inches stroke of piston. Sidewheels, 16 feet 5 inches diameter and 5 feet 11 inches face. Engines were geared to the shaft in proportion of 65 revolutions of the wheels for each 100 revolutions of the engines. Her trial trips were made April 15, 16, and 17, 1846. In 1847 the hull was converted into a lightship and stationed off the passes of the Mississippi River by order of the Secretary of the Treasury.

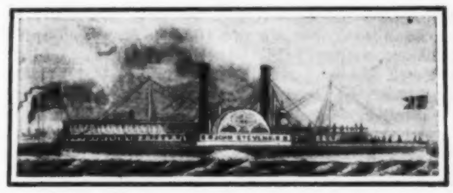
The "Spencer" was constructed by the West Point Foundry Association at Cold Spring, N. Y., and was ready for service in May, 1844. This vessel was of the same dimensions as the "McLane," and was originally fitted with Hunter's submerged wheels, but after several experimental trials, these wheels were removed and two Loper propellers, each 8 feet diameter with four blades, substituted. Her engines were of the same size as the "McLane's," and geared to propeller shaft in proportion of one revolution of the engine to 1.25 revolutions of propellers.

Both the "McLane" and the "Spencer" were very poor models, and in several experiments which were made with these vessels by the Revenue Marine Bureau in May, 1846, on Long Island Sound, from New London to Saybrook, to endeavor to find which was the most effectual and economical—the propeller or side wheel—the best speed that was to be obtained from either one under favorable circumstances was about 7 miles an hour. The hull of the "Spencer" was in 1848 converted into a lightship, and stationed off the James River, Virginia.

The "Polk" was contracted for and built by J. R. Anderson, of Tredegar Iron Works, Richmond, Va., December 4, 1844, and was a sidewheel steamboat of 128 feet by 26 feet by 10 feet 6 inches, fitted with two of Lighthall's half beam engines. She performed a few years of sea service, and in 1849 was converted into a bark, and subsequently sold at San Francisco, Cal., in December, 1854.

The "Walker" was built by Joseph Tomlinson, of Pittsburg, Pa., and was similar in size to the "Polk." She sailed from Pittsburg to New Orleans in December, 1847, and was transferred to the Coast Survey. Her draft of water was 6 feet 6 inches.

At this time the United States government were engaged in making many experiments with steam vessels, both for those in the naval service as well as those of other departments of the government, and of all the costly experiments of the period there was none that proved more valuable in experience than that with Hunter's submerged wheel, such as was placed on the "Alleghany" and other naval vessels. These iron vessels that were the first steam vessels in the Revenue Marine Service, were a great success as failures, in almost every regard in both hull and motive power. They cost about $85,000 each when finished. This was the period of the experimental stage of the screw propeller in this country, and has been noted as the time of the war of the propeller.



STEAMER "JOHN STEVENS," 1845.

John F. Starr, who had a machine and boiler shop at Camden, N. J., in 1843, built for the Baltimore and Philadelphia Steamboat Company the twin-screw propeller "Conestoga," she being 80 feet long, 16 feet beam, and 6 feet deep. He also built the boiler and propellers for the vessel, the latter being originally of Ericsson's patent. The engine was constructed by Reanie, Neafie & Co., and had a cylinder 16 inches by 16 inches.

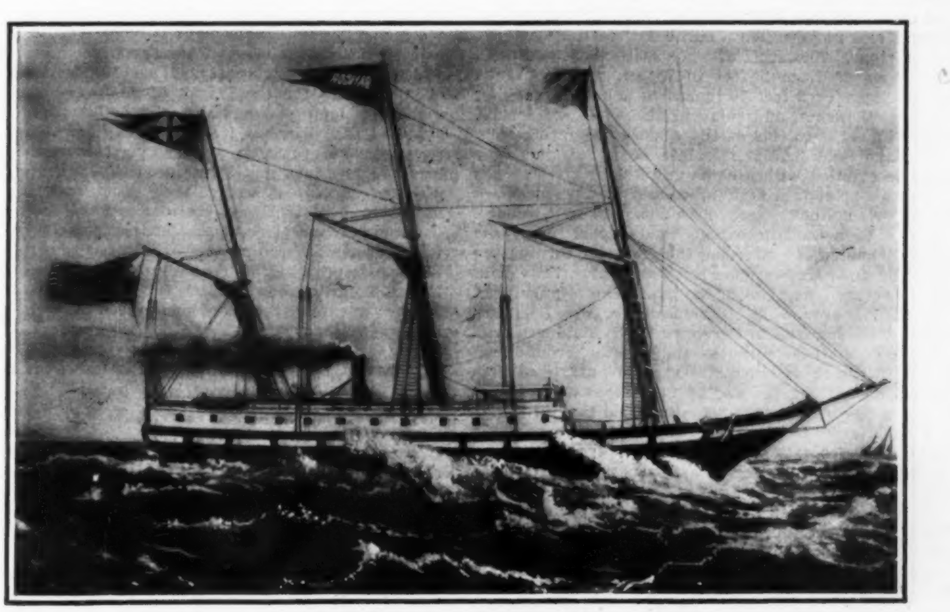
The West Point Foundry Association in April, 1844, commenced the construction at Cold Spring, N. Y., of an iron-hull vessel that was named "Margaret Kemble," for Myers & Co., of Norfolk, Va. This vessel was 92 feet by 17 feet by 7 feet. The bottom plates were ¼ inch thick, and sides of 3-16-inch iron. Deck of white pine and deck beams of yellow pine. Two wood bulkheads were fitted in the hold of the vessel. There were two horizontal engines, with cylinders each of 16 inches diameter by 24 inches stroke, and a boiler having 600 square feet fire surface, built for carrying 60 pounds pressure of steam. There was also fitted two Hunter wheels, 8 feet diameter and 2 feet wide, inside paddle 12 inches deep. These engines and wheels were subsequently removed, and a beam engine of 22 inches cylinder by 5 feet stroke, which had been taken out of one of the early New York and Brooklyn ferryboats, and the ordinary paddle wheels substituted in their stead. This vessel was in service in New York harbor as a towboat, and at one time was the property of the Morris Canal and Banking Company.

In the same year Betts, Harlan & Hollingsworth, of Wilmington, Del., or as now known, the Harlan & Hollingsworth Co., built for the Bangor Steam Navigation Co., of Maine, the "Bangor," a vessel of 450 tons for passengers and freight between Boston, Mass., and Bangor, Me. The frames of this vessel were made of bar iron fastened with iron clamps, and the plating was run in "clinker" built form, in place of the present in-and-out strake form. The vessel was fitted with twin-screw propellers. This was the first iron-hull steamer built for outside service in the merchant marine of the United States. She was 120 feet long by 23 feet beam and 9 feet depth of hold. There were two Loper propellers, 8½ feet diameter each, which were driven by two horizontal engines, each of 22 inches diameter of cylinder by 24 inches stroke of piston. The boiler was 20 feet long, and located in the hold of the vessel. On her second trip from Boston she took fire and was partially burned, but was afterward repaired and continued in the same trade until purchased in December, 1846, by the United States government at a cost of $28,975, and named the "Scourge," about the time of the breaking out of the Mexican war.

The Betts, Harlan & Hollingsworth Company built during the same year two propeller steamboats of 300 tons each for George W. Aspinwall, named the "Ashland" and the "Ocean," both of which vessels were in the service of the United States government during the war of the rebellion, and during which service they were lost. They were similar to those built for the Delaware and Raritan Canal. They also built during the same year the first iron-hull *ferryboat*, named the "Delaware," for the Winnisimmet Ferry Company, of Boston, Mass., of 270 tons, and in 1850 built a duplicate of the "Delaware," named "Winnisimmet," for the same company.

In 1843 and 1844 there was built at the Washington navy yard the iron-hull steamboat "Water Witch" on the plans of Lieut. Hunter, U. S. N. Her length was 100 feet 6 inches long, 21 feet 4 inches beam above the water line, and 16 feet 9 inches below the water line, and 9 feet 9½ inches depth of hold. There were two high-pressure engines, 22 inches diameter of cylinders and 4 feet stroke. She was also fitted with Hunter's submerged wheel, and built for use as a water boat at the Norfolk, Va., navy yard. Proving unsuitable for the purposes originally intended, in June, 1845, a contract was made with R. F. Loper to add 30 per cent to the length of the vessel, and to build other engines, boilers, and machinery to operate Loper propellers. The execution of this work was done by Reanie, Neafie & Co., of Philadelphia, Pa., for the contractor. Prepared for use as a dispatch boat in the Gulf of Mexico, and complaints having been made of her performance, the Secretary of the Navy ordered her to be put out of commission November 6, 1845. In July, 1846, the department authorized the substitution of a new engine and boilers and side wheels, and the addition of materials to strengthen her hull. This was done at the Washington navy yard. In November, 1847, the vessel with these alterations and repairs was in service with the Home Squadron until 1848. In 1850 several of the bottom plates were found to be affected by corrosion for want of paint. In 1851 she was again repaired and a new horizontal tubular boiler fitted. In the same year this boiler was altered by James Montgomery, of Baltimore, Md., but after a trial was condemned as unfit for service. Having been reported "totally unseaworthy" on January 7, 1852, on the 17th of March that year the department authorized her to be rebuilt of pine wood, using the engine then in the vessel. The original cost of the vessel was $53,122, and the alteration to a propeller $37,989. They learned better how to take care of an iron vessel at a much later date, but the learning was expensive and came through experience.

In 1844 there was also built by John F. Starr, at Camden, N. J., a small sidewheel boat of iron named "Independence." This vessel was 90 feet long, 15 feet beam, and 5 feet hold, and had a high-pressure oscillating engine 16 inches cylinder by 6 feet stroke, with one boiler in the hold. The machinery was built by I. P. Morris & Co. She was used for a passenger boat between Philadelphia and Bridgeport, N. J., until about 1850, when all her passenger accommodations were removed and she was put to towing on the Delaware River. Average steam pressure, 75 pounds. At one time she had the name of "W. G. Thomas" on her water-wheel houses, while her original name was on the stern. This was permitted at that early date.



STEAMER "BANGOR," 1844.

In the same year the Novelty Iron Works, of New

York, constructed a small twin-screw propeller named "Albemarle" for service through the canal from Norfolk to North Carolina Sound. This one was similar to those on the other canals. She remained there but a comparatively short time.

Jesse W. Starr, of Camden, N. J., also built same year for the Delaware and Raritan Canal Company the sidewheel tow barge "Camden," about 130 feet long by 20 feet beam. This vessel was entirely of iron including the deck frame, deck, and wheel houses, and was fitted with a square engine.

There was also built by the Novelty Iron Works in 1844 a small sidewheel iron-hull boat of 133 tons, that was taken down and re-erected at Buffalo, N. Y., in the summer of the same year, for the engineer corps of the United States army and named "Abert." The name was changed to "Surveyor" in 1849. The vessel was used for the survey of the northern and northwestern lakes until 1875, was then sold and used as a ferryboat on the St. Clair River.

The propeller "Naugatuck" was built in the same year (1844) for the Ansonia Brass and Copper Company by Henry R. Dunham & Co., one of the large marine engine builders of that day, at the foot of West Thirty-third Street, New York city. This vessel was built to run between New York and Derby, Conn., mainly to transport the product of the Ansonia company to the metropolis. The vessel was 105 feet long on deck, 96 feet 8 inches between perpendiculars, 20 feet 4 inches breadth of beam, and 6 feet 8 inches depth of hold; custom-house tonnage 120 50-95 tons. There were two engines with inclined cylinders, each 16 inches diameter by 24 inches stroke, with one boiler, fan blower, and blower engine. The Ericsson screw propeller was 6 feet in diameter. There was a small cabin on deck fitted with 24 berths for passengers. This vessel ran to Derby for about three years, when she was sold to Edwin A. Stevens, of Hoboken, N. J., the Ansonia company building the sidewheel boat "Ansonia" to take her place.

The most noteworthy points in the history of the "Naugatuck" are the experiments made on her by Mr. Stevens in 1857 to test the difference between the ordinary screw and the ordinary paddles of a sidewheel boat, and also to compare the effect produced by each of these with that produced by a single paddle placed in the center and projecting below the bottom of the vessel; and further, her conversion, in the latter part of 1861, into a war vessel, and the alterations and additions made by him to adapt her to that service.

The experiments in 1857 were made at Bordentown on the Delaware River. The draft of water of the vessel was 5 feet, her screw was 6 feet in diameter and had a pitch of 15.29 feet. The side wheels were 10 feet in diameter, and the paddles were 4 feet long and had a dip of 16 inches. The central wheel had the same diameter as the side wheels, but the paddles were twice as long, viz., 8 feet. There was but little difference, either in speed or in effect, between the screw and the paddles; but they were both very far superior to the paddle placed within the hull. This vessel was converted into a vessel of war and presented to the United States government early in 1862. The alterations were the substitution of twin screws for the single screw; the addition of two large tanks at bow and stern to submerge the vessel to a certain extent; the addition of very thick bulwarks of white pine to give buoyancy to the vessel when the deck was submerged, the addition of two rotary pumps to empty the tanks, and the addition of a 10-inch gun placed amidships on deck, pointing in an immovable direction in line with the keel over the bows, but arranged to be elevated or depressed, and recoiling on a stationary carriage against rubber rings. The draft of water with these additions was increased from 5 feet to 7 feet, and the tanks when full added 2 feet 10 inches to her draft, making it 9 feet 10 inches, and submerging her deck 6 inches, so as to flood it to this extent when going into action. The tanks held 3,075 cubic feet of water, and they could be emptied within eight minutes.

The two principles first introduced in naval warfare by the "Naugatuck" were the submerged hull, rendering her to a certain extent "water clad," and the method adopted of traversing the gun, viz., turning the vessel by twin screws upon her own center, thus making this center the pivot of the gun. The "Naugatuck" was turned around by this means in the Delaware River at Bordentown in December, 1861, making a complete turn in three minutes and turning around and around without advancing. The advantage of this method of training the gun by twin screws was shown in the action between the "Monitor" and the "Virginia" and "Merrimac" in May, 1862, when the accuracy of the shots fired from the "Naugatuck" delivered at long range was greatly admired and generally commented upon.

This vessel was in service during the period of the rebellion in the James River and the sounds of North Carolina as a gunboat, and at its conclusion was converted into a vessel for service in the more peaceful pursuits of the revenue marine service. She was thoroughly overhauled in 1871, and again in 1877, and was then mainly employed in Pamlico Sound and Albemarle Sound on the coast of North Carolina. Her draft of water at that time was 5 feet 6 inches. Since her entry into the revenue marine service, her name has been changed to "E. A. Stevens." The vessel was disposed of by the bureau on April 24, 1890, to Henry Brown, of Baltimore, Md.

In 1845 Betts, Harlan & Hollingsworth Company built for Anthony Raybold a sidewheel iron-hull steamboat of 186 x 20 x 7 that was named "W. Whilden." This vessel was afterward altered to a propeller, her name changed to "Gen. Cadwallader," and run through the canal between Philadelphia and Baltimore until 1902, when laid aside from further use.

In the same year Hogg & Delamater, of New York, built at the foot of Jane Street the "Iron Witch" from designs furnished by John Ericsson. Her dimensions were 222 feet 2 inches in length, 27 feet beam, and 10 feet 6 inches depth of hold. The motive power was a pair of inclined engines, each 60 inches by 5 feet stroke, and ample boiler power for a working pressure of 50 pounds of steam. The owners were R. B. Forbes and J. M. Forbes, of Boston, Mass., M. O. Roberts, of New York, and others. This vessel was originally fitted with small side wheels about 16 feet diameter, with the intention to give them a velocity of 35 or 40 revolutions a minute, and thus gain a high speed for the vessel; but the result proved that the highest steam pressure obtained gave only 30 revolutions per minute, and this gave the vessel no advantage in speed over the sidewheel boats then on the Hudson River. The side wheels were after a few months removed, and screw propellers of about 14 feet diameter fitted at the sides of the vessel in place of the radial wheels, and geared for a high velocity. This experiment was found to be "that the last stage was worse than the first," and after several trials the boat was laid up. Subsequently the machinery and propellers were removed, and a vertical beam engine built by H. R. Dunham & Co. fitted in the vessel with the ordinary side paddle wheels, after which she ran as the "Erie" in connection with the Erie Railroad until 1860, when the engine was placed in the ferryboat "Pavonia," now "Rutherford," on the Erie ferry, and the hull converted into a freight barge. The hull was subsequently planked with wood, and was in service a few years ago.

The "Iron Witch" was one of Ericsson's most signal failures. His weakness lay in the fact that the world knew of all his failures, but there were other designers who made as great errors of professional judgment and fact as he, but the world has never been the wiser of the results of their experiments, on account of the secrecy thrown around them. He expected with very small side wheels, high steam, and large engines, with about forty revolutions, to excel any steamboat on the Hudson River in speed.

Otis Tufts, of Boston, Mass., built in 1846 a wrecking tug of 320 tons named "R. B. Forbes" for the underwriters of Boston. She was fitted with a pair of condensing engines, each 36 inches by 32 inches, driving Ericsson twin screws, and two boilers also built by the same builder. She was sold to the Navy Department in 1861 for $52,500, and was wrecked on the coast of North Carolina February 25, 1862.

Jesse W. Starr built for the Delaware and Raritan Canal Company the same year the tow barge "Mars." She was originally about 90 feet long, as the locks on the canal at that time would not permit of vessels over 100 feet in length, but she was afterward lengthened.

In 1845 the Camden & Amboy Railroad Company had built at the yard of Robert L. and E. A. Stevens, at Hoboken, N. J., the iron-hull steamboat "John Stevens" for passenger service on the upper end of their railroad line, from Amboy to New York. A description of this vessel is given in a mechanical journal of 1846: "Her hull is made of the best quality of Pennsylvania plate and rib iron; the plate iron being ¼ inch thick and the rib iron of the angle form, with this difference from the common angle iron, that there is more iron on the top edge and less in the body, just contrary to the common form. The ribs are placed 2 feet apart center to center, except immediately under the engine, where they are 1 foot apart. The size of the ribs is 3½ inches by 2¼ inches, weight 7½ pounds per lineal foot. She has four keelsons of ½-inch iron, with angle iron riveted on top edge. They are 3 feet deep, two of which stand 12 feet apart and are 164 feet long, the ends tapering for the length of 46 feet down to 12 inches in depth, upon which the boilers rest, which stand 41 feet 6 inches apart, fore and aft. The other two keelsons are those upon which the engine rests, being 72 feet long and 3 feet deep in the center for a distance of 24 feet, the balance being reduced to 12 inches in depth. These keelsons are all fastened to one another and sides of the boat by cross keelsons 3 feet deep, and of a distance varying from 3 to 10 feet. She is also provided with a watertight bulkhead of iron 27 feet from the bows, which is a great safety to passengers in case of the bows being stove in, which often happens with great loss of life and property. Being intended for a day boat, and not having been fitted up with berths, her cabins are very airy, light, and roomy.

Length on deck	245 feet
Breadth of beam	31 feet
Breadth over all	65 feet
Depth of hold	11 feet
Diameter of water wheels	31 feet 8 inches
Face of water wheels	12 feet
Dip	2 feet 7 inches
Tonnage	800 tons
Draft of water	5 feet

"Her engine is of that kind known as the 'steeple' engine, improved by the addition of double-connecting rods, with vibrating cross-head which passes through main cross-head, and works upon guides by balance valves fitted with expansion gear to cut off the steam at from ¼ to 2-3 of the stroke of the piston, and also by an improvement in the air pump bucket, which has a circular double opening valve. The engine was made by T. F. Secor & Co., of New York.

Diameter of cylinder	0 feet	75	inches
Stroke of piston	8 feet	0	inches
Diameter of air pump	0 feet	31	inches
Stroke of air pump	8 feet	0	inches
Diameter of force pumps	0 feet	3½	inches

"Boilers of a tubular construction 15 feet long and 12 feet wide, each having 384 tubes 12 feet long and 1¾ inches bore.

"For further safety in case of leakage, she is provided with a bilge injection, of a capacity sufficient to supply the air pump with as much water as it will lift with the ordinary speed of the engine. Also as a further security against damage to the rudder from ice or other floating substances, it is placed under the run of the vessel, the upper edge being 2 feet below the water line.

"The model of this boat was made by Mr. Robert L. Stevens; the drafts of the engine were also furnished by him. We will farther mention that there are many improvements in the details of the hull of the 'John Stevens' that have been introduced by Mr. R. L. Stevens, among which are the peculiar form of the rib iron first introduced on her and since extensively used in England, and the arrangement of diagonal iron braces outside the hull above the water line. Her cost was a little upward of $100,000."

This vessel was burned several years ago, but was afterward rebuilt and fitted with a pair of propeller engines and twin screws in place of side wheels, and has been used as a freight and cattle boat by the railroads in New York waters. In 1903 she was laid aside from further use.

(To be continued.)

THE CHEMISTRY OF ELECTRO-PLATING.*

By Wilder D. Bancroft.

In a paper on the above subject presented to the Franklin Institute, the author presents the most recent facts relating to the electrolytic precipitation of the metals. The author stated that his object was to show that many of the peculiarities attending the electrolytic precipitation of metals become clear when we consider the chemistry of the reaction and follow out chemical analogies. For the purposes of discussion he defines a good deposit as one in which the metal comes down in a pure, fairly adherent, reguline form. Except possibly in the case of treeing, a bad deposit apparently is due always to the precipitation of a salt of the metal. This is usually an oxide or hydroxide, but may be a simple cyanide in cyanide solutions. It is often stated that the precipitation of hydrogen makes a deposit bad. There seems to be a confusion here between cause and effect. In electrolytic analysis hydrogen is evolved and yet the deposit remains good. Further, the so-called critical density varies enormously with the size, shape, and distance apart of the electrodes, and also with the size and shape of the containing vessel. The most important factor is the rate of stirring. If a solution gives a good deposit at some current density it seems probable that a good deposit can be obtained at any higher current density provided the stirring is sufficiently rapid to prevent impoverishment of the film at the surface of the cathode. When a deposit becomes sandy or changes to a black powder with increasing current density, the polarization shows that there has always been the formation of a dilute solution at the cathode. In most cases this leads to the precipitation of an oxide or basic salt, with the usual disastrous results.

If a bad deposit is always due to the precipitation of a salt, the addition of anything that will dissolve the salt readily under the conditions of the experiment will prevent its deposition, and should therefore improve the quality of the deposit. I have made a list of the more important additions recommended in the refining, analysis, or plating of zinc, nickel, lead, tin, copper, and silver. These are given in Table I.

Table I.

Zinc.	Tin.
Sulphuric acid	Sulphuric acid
Potash	Potash
Ammonium chloride	Sodium pyrophosphate
Ammonium sulphate	Potassium carbonate
Aluminium sulphate	Acid potassium tartrate
Potassium cyanide	Potassium cyanide
Acid potassium oxalate	
Nickel.	**Copper.**
Sulphuric acid	Sulphuric acid
Ammonia	Ammonia
Ammonium salts	Alkaline tartrate
Potassium cyanide	Ammonium oxalate
Sodium bicarbonate	Potassium cyanide
Sodium bisulphite	Sodium bisulphite
Lead.	**Silver.**
Acetic acid	Nitric acid
Potash	Ammonia
Fluosilicic acid	Potassium cyanide
Sodium nitrate	Potassium iodide

All the substances under zinc dissolve zinc hydroxide. The first four under nickel dissolve nickel hydroxide; the sodium bicarbonate probably serves to keep the acidity constant; while the sodium bisulphite occurs only in solutions containing free ammonia. All the substances under lead dissolve lead hydroxide. Stannous and stannic acids are soluble in sulphuric acid, in potash, and in a so-called sodium pyrophosphate solution; potassium carbonate is added only to neutralize an excess of free acid in stannous chloride solutions; while the cyanide and tartrate seem to be of very little value, unless perhaps at the anode. Under copper, everything dissolves the hydroxide except sodium bisulphite, and this is added to cyanide solutions to prevent loss of cyanogen when the copper changes from the cupric to the cuprous form. All four

* Mechanical Engineer.

substances under silver dissolve freshly-precipitated oxide; in addition, ammonia dissolves silver chloride, while silver cyanide and silver iodide are soluble in potassium cyanide and potassium iodide respectively.

It is thus clear that there is a simple rational basis for many of the solutions in actual use. It must be kept in mind, however, that the rate of solution is more important than the actual solubility. Thus it is not easy to get a good deposit from an alkaline zincate solution at 20 deg., whereas it is a comparatively simple thing to do this at 40 deg., because the caustic soda reacts with zinc oxide or hydroxide much more rapidly at this temperature. It does not follow from this that a higher temperature would necessarily be even better. At 90 deg. the action of caustic soda on metallic zinc becomes an important factor. With copper sulphate solutions, rise of temperature means increased formation of cuprous sulphate, and this must be taken into account. In each of these cases a study of the chemical reactions shows the cause of the difficulty.

We now come to the more interesting side of the question—to the factors affecting the size of the crystals in electrolytically-deposited metals. It will be well to run over briefly what our chemical analogies would lead us to expect, and then we can consider how closely the predictions are fulfilled.

Rapid crystallization of a salt from solution gives us small crystals, while slow crystallization leads to larger crystals. We should, therefore, expect the crystalline structure of the electrolytically-deposited mettals to be finer the more rapid the precipitation, in other words, the higher the current density. At high temperatures chemical precipitates are more crystalline than at lower temperatures. Two striking instances of this are barium sulphate and alumina. If we increase the difficulty of precipitation we should expect that the crystals would have more difficulty in reaching a large size. We therefore conclude that we shall get a more nearly amorphous deposit from a dilute solution than from a concentrated one, provided all conditions remain the same. We can generalize this and say that the greater the potential difference between metal and solution the finer will be the electrolytic deposit. At one time I thought that this could be carried still farther, and that we could say that neutral solutions would give coarser deposits than acid ones; that oxidizing agents would cause fine deposits and reducing agents coarser ones. Further experiments have shown that this is not generally true, and that the effect varies from metal to metal and sometimes from concentration to concentration.

We know that the addition of a colloid to a solution increases the probability of a precipitate coming down colloidal, and that chemically-precipitated metals are rarely pure. From this we conclude that addition of a colloid to a solution will make the electrolytic deposit more finely crystalline, and that the carrying down of substance with the metal will tend to make an amorphous deposit, always provided that the substances carried down do not spoil the deposit entirely.

We can now consider the experimental results. With zinc sulphate, sodium zincate, copper sulphate, silver nitrate, and stannous chloride solutions, the crystals become smaller as the current increases. The silver nitrate solutions were especially interesting. At St. Louis, last summer, the point was raised that it was impossible to obtain a fine-grained deposit of silver from silver nitrate solutions, no matter how high the current density was raised. In our first experiments with silver nitrate it was not possible to detect any effect due to current density. This was somewhat discouraging. Since a silver salt is formed at the anode which increases the weight of the cathode deposit, it was thought that this same salt might affect the crystalline structure of the metal. The experiment was repeated using a porous cup to separate the anode and cathode solutions. We then obtained smaller crystals with higher current density. With 20 amp. q.d.m. the deposit could be burnished.

With an acidified copper sulphate or zinc sulphate solution the deposit became coarser as the temperature was raised from 20 deg. to 40 deg. and to 70 deg. With a zinc sulphate solution which was only faintly acid, the deposit was coarser at 70 deg. than at 40 deg., but was coarser at 20 deg. than at the other two temperatures. I suspect that at 20 deg. the slight acidity had no appreciable effect on the deposit, while it became an important factor at 40 deg.

The effect of concentration is that required by the theory. With zinc sulphate, sodium zincate, copper sulphate, and silver nitrate solutions, smaller crystals were obtained from the more dilute solutions than from the more concentrated ones. The deposit from the zinc sulphate solutions was coarser than that from the sodium zincate solutions, these last being very smooth. It is a recognized fact that silver and copper precipitate well from potassium cyanide solutions. Silver nitrate in pyridine gives a finer deposit than in aqueous solutions. From sodium stannate solution much smaller crystals were obtained than from a stannous chloride solution.

The addition of sulphuric acid to a neutral solution of copper sulphate makes the deposit much finer. We have not yet noticed a corresponding effect with any other metal, and are therefore forced to believe that this is characteristic of copper, in which case it is probably connected with the presence of cuprous sulphate in the neutral solution. This point cannot be considered as settled definitely. The addition of formaldehyde made the metal deposited from zinc sulphate solution finer, while it coarsened that from the zincate solutions. Addition of formaldehyde improved the deposit from copper sulphate solutions, while the addition of a good deal of nitric acid made the copper crystals finer than when deposited from a neutral solution, but coarser than when deposited from a solution acidified slightly with sulphuric acid. An excess of nitric acid makes the deposit from a silver nitrate solution coarser at high current densities and finer at lower densities.

Coming next to the question of colloids, we know that the addition of glue to lead fluosilicate solutions improves the quality of the deposit enormously. In the laboratory we have tried the effect of 10 grains of glue per liter. With zinc, copper, and tin, the crystalline structure was much smaller than without the glue. With a silver nitrate solution we obtain a violet deposit which is apparently amorphous silver. Though we have not yet had time to test this thoroughly, it seems probable that we have here an explanation of "bright" deposits. A bright deposit is one in which the crystals are so small that the deposit is practically amorphous. By using less glue in our silver nitrate solution we could probably get a fairly bright deposit. We have not yet analyzed the silver deposit from a solution containing glue, but it is probably not pure. Carbon bisulphide is the substance most often added to silver cyanide solution to cause a bright deposit, and this bright silver is said to contain sulphur. When too much carbon bisulphide is present, the deposit is said to become black. I think that it has usually been assumed that this black color was due to silver sulphide; but it now seems possible that a violet colloidal silver is precipitated. Jordis states that bright deposits of many of the metals can be obtained from lactic acid solutions. Since the metal deposited from a solution of an organic acid may easily contain carbon, it becomes quite possible that there is an intimate connection between the two facts.

It has been noticed by many observers that a bright or burnished deposit can be obtained when one rotates the cathode and uses high current densities. Those who made these experiments were interested primarily in increasing the current density, and they varied the speed of rotation and the current density simultaneously. Consequently, one did not know whether the burnished effect was solely the result of the current density or not. To test this question, Mr. Snowdon made some experiments with a silver cyanide solution and a rotating cathode. The current density and speed of rotation were so adjusted that a bright deposit was obtained. Then the speed of rotation was kept constant while the current density was increased. Since an increase of current density would decrease the size of the crystals, the deposit should have become even brighter if the current density were the only factor. As a matter of fact the deposit was distinctly frosted. The only explanation that I have been able to find is that at the moment of precipitation there is a polishing effect due to surface friction. If more metal is deposited in the unit of time than can be polished, the metal is frosted. While this explanation may not seem satisfactory to everyone, it does account for the facts, and this is certainly a point in its favor.

It has been noticed that the presence of salts of cadmium, iron, lead, and copper interfere with the satisfactory precipitation of zinc. The reason for this is very simple. These metals precipitate before zinc and set up a local circuit which oxidizes the zinc and causes the deposit to become faulty. This local circuit may make trouble in other cases. When we have to plate a noble metal on a less noble one, we usually make use of a striking bath, in which the difference of potential between the two metals is not very great. This keeps down any non-electrolytic precipitation to a minimum. When we are depositing a less noble metal on a more noble one, we never bother ourselves about the formation of a couple, and we may be thereby led into serious error. Zinc will precipitate nicely on a zinc cathode when it will not deposit well on a copper cathode owing to the evolution of hydrogen. The difficulty about precipitating zinc with a low current density is due chiefly to local action at the cathode. It seems probable that this also accounts for its being so much more difficult to precipitate lithium on a platinum electrode than on an iron one.

Another point of importance to the plater is the adhesion of the deposit. While it has been suggested that an adherent deposit can be obtained only when the two metals can combine to form compounds or solid solutions, this contention does not seem to be in accord with the facts. The surface between two metals is a thin weld, and it must show the same strength, no matter how it has been made. In other words, the adhesion of an ideally-made electrolytic deposit will approach that of a casting having the same size of crystals. Presence of grease, of air-bubbles, or of occluded mother-liquor will impair the contact and weaken the joint. If the metal be deposited in a state of strain, the break will come at the weakest point. These are matters of general knowledge in making welds or castings, and they are just as much first principles in electrolytic work. No one seems to have been struck by the absurdity of the statement, to be found in most books on plating, that nickel cannot be plated on nickel, because it will not adhere. If this were true it would not be possible to deposit more than an infinitesimally thin film of nickel electrolytically. While it requires a higher voltage to deposit nickel than copper, nickel does not precipitate copper to any appreciable extent when immersed in a copper sulphate solution. The nickel becomes passive, and is probably covered with a thin film of oxide. What is meant is that an "active" nickel containing hydrogen will not adhere to a "passive" nickel. There is nothing surprising or mysterious about this. By making a nickel electrode the cathode in an acid solution for a few minutes before putting it in the nickel bath, Mr. Snowdon has been able to plate nickel on nickel, getting a beautifully adherent deposit.

The theory which I have outlined for you has been able to account for the phenomena due to added salts, current density, temperature, concentration, solvent, colloids, other metals, and cathodes. It has not accounted for the effect of acids, oxidizing agents, and reducing agents; but this seems to be due to our ignorance of the chemistry of these solutions.

A MECHANICAL VIEW OF DISSOCIATION IN DILUTE SOLUTIONS.*

THE view that the phenomena of solution depend on the relative kinetic energy of the solvent and solute molecules appears to apply with special force to the phenomena of dissociation in dilute solutions. Under the gas theory there does not appear to be any reason why the solute molecules should dissociate into their ions. So obvious is this absence of any physical motive that Prof. Armstrong has happily referred to the dissociation as "the suicide of the molecules." Others have proposed to ascribe the phenomenon to what might be called "the fickleness of the ions," thus supposing that the ions have an inherent love of changing partners. These may be picturesque ways of labeling certain views of the situation, but the views themselves do not appear to supply any clue to the physical nature of the phenomena. With the acceptance of the view that the phenomena of solution are largely due to the kinetic energy of the solvent molecules, the phenomena of dissociation also appear to take their place as a natural result of this activity. For consider the situation of an isolated molecule of cyanide of gold and potassium closely surrounded by and at the mercy of some millions of water molecules all in a state of intense activity. The rude mechanical jostling to which the complex molecule is subjected will naturally tend to break it up into simpler portions which are mechanically more stable. The mechanical analogy of a ball mill in which the balls are self-driven at an enormous velocity is probably rather crude, but it may at least help us to picture what, on the view now advanced, must be essentially a mechanical operation.

In importing this mechanical view of the breaking down of complex into simpler molecules we are not without some solid basis of facts to go upon. My own observations have shown that even in the solid state the crystalline molecule can be broken down by purely mechanical means into the simpler units of the amorphous state; and, further, that the water molecules of a crystal may by the same agency be broken away from their combination with the salt molecules. Since the publication of the earlier of these observations Prof. Spring has shown that the acid sulphates of the alkali metals may be mechanically decomposed into two portions, one of which contains more acid, and the other more base than the original salt. It is important to recognize that in these three apparently short steps the transition has been made from the overcoming of the simple cohesion of similar molecules in contact with each other to the breaking asunder of the chemical union of dissimilar molecules. At each step the solid molecules appear, not as mere ethereal abstractions, but as substantial portions of matter which can be touched and handled mechanically.

The physical properties of a gas are primarily due to its being an assemblage of rapidly moving molecules. These simpler and more general properties can coexist with, and may be modified by, the more complex relations introduced by chemical affinity as it occurs in compound gases and mixtures.

It appears to me quite legitimate similarly to regard the physical properties of a liquid as due to its being an assemblage of rapidly moving molecules. The liquid system is highly condensed, and the motions of its molecules are controlled by the cohesive as well as by the repulsive forces. The closer approximation of the molecules may reduce their mean free path to an extremely small amount, or it may even cause their translatory motion to disappear, so that the whole kinetic energy of the liquid molecules may be in the form of rotation or vibration.

As we can imagine a perfect gas, so also may we imagine a perfect liquid, the physical properties of which are as simply related to the laws of dynamics as are those of the gas. But the conditions of the liquid state being also those most favorable to the play of chemical affinity, the internal equilibrium of solutions or of mixed liquids must be a resultant of this affinity together with the primary forces of the ideal liquid state.

An ideally perfect solution—that is, a solution the physical properties of which are determined solely by the number of molecules it contains in a given volume—must consist of a solvent and a solute which have no chemical affinity for each other, so that their molecules will neither associate nor dissociate in solution. Probably only comparatively few solutions will be found which even approximate to this ideal perfection. But it appears to me that the study of the problems of the liquid and the dissolved states may be much simplified by the recognition (1) that the primary physical properties of liquids and solutions are due to the fact that they are assemblages of molecules endowed with the amount and the kind of kinetic energy which is proper to their temperature; and (2) that as these primary physical properties of the liquid and dissolved states may be masked and interfered with by chemical affinity, they should be studied as far as possible in examples where the influence of this force is either absent or at a minimum.

* From an address by G. T. Beilby delivered before the British Association for the Advancement of Science.

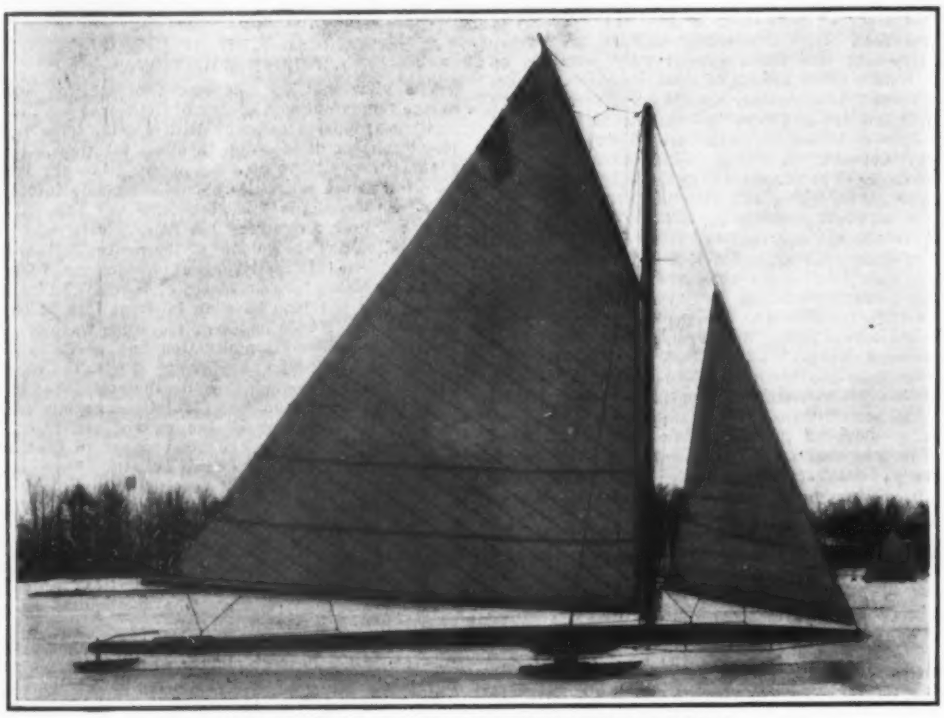
IMPROVED ICE YACHT CONSTRUCTION.

HOLLOW BACKBONE AND 250-SQUARE-FEET SAIL AREA.

By H. PERCY ASHLEY, I. Y. A.

THE first printed set of plans for an ice yacht appeared in the SCIENTIFIC AMERICAN SUPPLEMENT of March 17, 1877. A comparison of that draft and the accompanying plans will clearly show the great strides in construction to obtain faster time. In those days the ice yachts often ran away with the steersman and were beyond control. Science and mathematical calculation now put them absolutely under the racing skipper's hand.

For an all-around and fast ice yacht that can be used the greatest number of days the 250-square-feet sail area class has proved the most satisfactory. This class has been raced with great success at the well-known Orange Lake Ice Yacht Club, situated a few miles back of Newburg, N. Y. This class has been adopted by the Stockholm Ice Yacht Club, of Stockholm, Sweden. The advantages of this ice yacht are its light construction, comparatively small sail spread, with powerful driving power, which, combined with balancing power, make the essential for fast time on the ice.



AN IMPROVED STYLE OF ICE RACING YACHT.

The backbone and runner plank should be of well-seasoned basswood free from knots or checks. The spars are hollow and are of spruce; runners of seasoned best white oak; cockpit or steering box of white oak; top and bottom cap for backbone of white oak.

The general dimensions are as follows: Backbone or center timber over all 30 feet; thickness 4½ inches; width 11 inches at runner plank; nose 3¼ inches; heel 4¾ inches; runner plank over all 16 feet 8 inches; cut of runners 16 feet; spread shrouds 8 feet 5 inches; length of cockpit 7 feet 6 inches; width 3 feet 7 inches; depth 4 feet. The total sail area is 248.60 square feet.

Construction of Backbone.—Select two pieces of well-seasoned basswood as dressed 30 feet long by 10 inches wide and 1¼ inches thick. Dress in shape of backbone which will be 2½ inches at nose, 4⅛ inches at heel, and 10 inches at mast and runner plank. The struts are of white pine, 2 x 2 inches, and are glued and screwed on the sideboards at an angle of 45 degrees. Start struts at the mast, which is 9 feet 6 inches aft of the nose. Oak 2 inches thick is inserted at the nose, mast, runner plank, fore end of cockpit, and heel. (See plate 2, No. 13.) Nos. 10, 11, and 12 show inside mid-section and outside construction of backbone; 13 is the inside construction complete without the port side screwed in place. Firmly glue and screw with brass screws all contact parts. The backbone is capped on the upper and lower sides with ½-inch oak. The nose and heel end in a shoulder to receive the loops for wire rigging that form the runner-plank guys. (Plate 1, deck plan.)

Runner Chocks, etc.—The runners are of seasoned white oak pierced with ⅝-inch bolts with screw head. The runner shoe is soft cast iron. The cutting edge fore and aft has a downward curve of 1-16 inch. The dimensions of fore runners are as follows: Over all, 4 feet 8½ inches; depth of wood at center, 4¾ inches; width, 2¼; depth of shoe, 2¼. Rudder, over all, 2 feet 11 inches; width, 2 inches. Depth of oak, 3 inches; depth of shoe, 1¾ inches; rudder post, 1¼ inches circumference; length of tiller, 3 feet. The chocks or runner guides are of white oak and are of the following dimensions: Over all, 21 inches; depth, 4 inches; width, 1¾ inches. They are fastened to runner plank with ½-inch lag screws. (See plate 2, Nos. 1, 3, 7, and 8.) Fig. 2 shows enlarged mid-section of fore runners. (See plans.) Runner plank is 16 feet 8 inches over all and the fore runners have a cut of 16 feet. The straddle of the shrouds is 8 feet 5 inches; width at ends, 12 inches; center, 13¼ inches; depth at center, 4¼ inches; ends, 2½.

Spars, Sails, Rigging, etc.—The spars are of hollow spruce. The dimensions of the sails are as follows: Main sail hoist, 12 feet; gaff, 10 feet 3 inches; leech, 24 feet; boom, 18; diagonal, 20 feet 3 inches; jib on stay, 12 feet; leech, 9 feet 9 inches; foot, 7 feet 3 inches. The standing rigging is ¼ plow steel, the running rigging for sails 5-16 for peak and jib halyards, and ⅜ diameter steel running rigging for throat halyards. The main sheet and jib sheet are rove through bull's eyes. The mainsail contains 212.60 square feet, jib 36 square feet, making a total of 248.60 square feet. The dimensions of the sails call for fully stretched.

The cockpit is 7 feet 6 inches long and 43 inches wide. It is formed of two bent oak strips 2 inches wide and 4 inches deep, with a groove in the under side to receive a flooring of tongued and grooved ½-

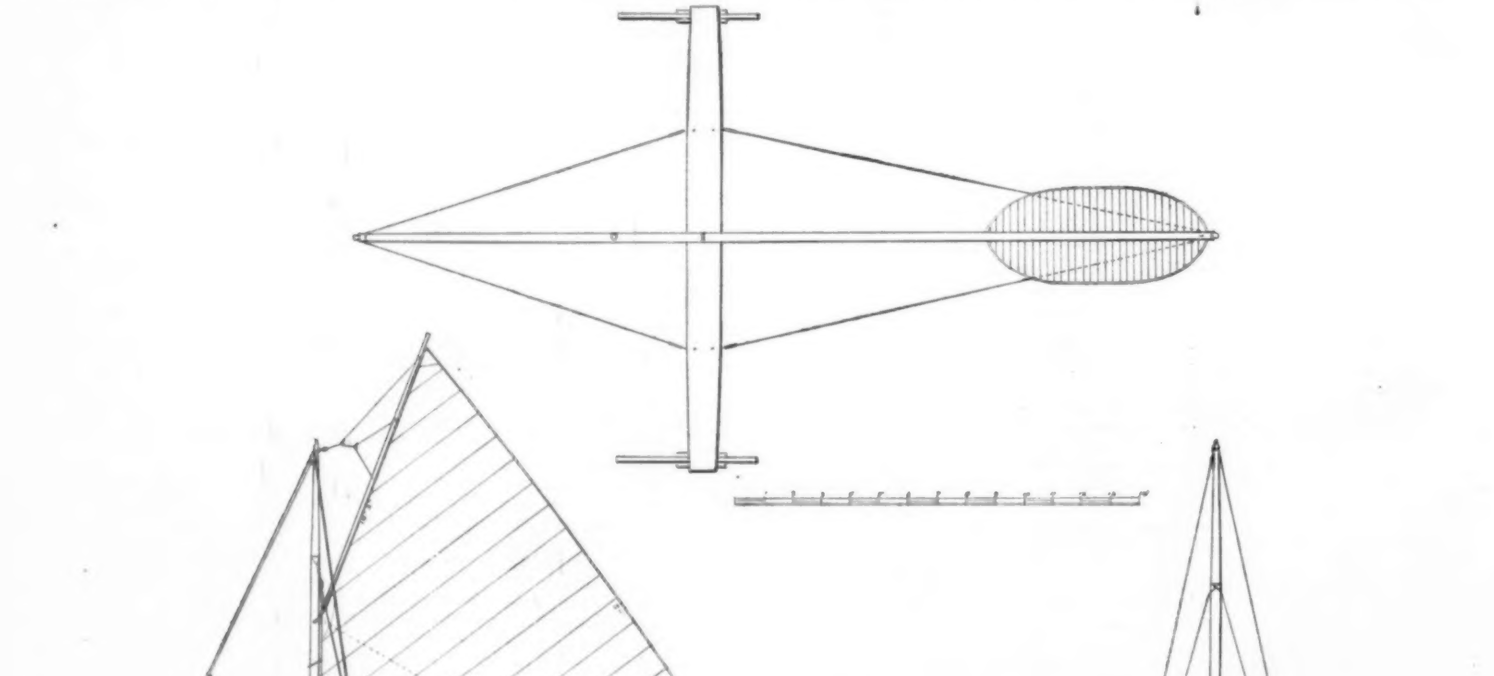


PLATE I.—ICE YACHT CONSTRUCTION.—PLAN OF SAIL AND RIGGING.

inch oak 4 inches wide. All contacting surfaces are glued and screwed in place. The very best time to build an ice yacht is in the fall and it should always be built under cover. A canvas cover is essential to protect the cockpit from the weather. The bob stay is of ½-inch diameter Scotch iron and ends in a right-and-left turnbuckle with jam-nuts at the aft end. All shrouds and runner plank guys end in loops. The turnbuckles are ⅜-inch thread Tobin bronze and the blocks are No. 1 bronze with wire rope sheaves.

KEY TO PLATE 2.

1. Runner plank with chocks and brace.
2. Enlarged mid-section of fore runners.
3. Lower side of fore runner chocks and braces.
4. Tiller, rudder post, and rudder runner.
5. Mid-section of same.
6. Mid-section for runner.
7. Side view of chocks, showing lag-bolt fastening to runner plank.
8. Top of fore runner.
9. Side of fore runner.
10. Inside construction of backbone.
11. Mid-section construction of backbone.
12. Outside construction of backbone.
13. Inside construction of backbone complete without port outside plank.

tion will be kept as free from technicalities as possible, and will be made more precise by means of figures officially placed before the court martial on the foundering of "A 8."

A submarine, at her lightest draft, in the "surface" condition, has her largest circular cross-section amidships immersed to about five-sixths of the diameter. The water-level, in other words, is only about one-sixth of the diameter below the "crown of the arch" on that cross-section. It will be easily understood, therefore, that if a submarine were built of strictly cylindrical form, with cross-sections of uniform diameter from end to end, the breadth at the water-line in the surface condition would be much less than the diameter, and every inch of additional immersion would be accompanied by a proportionately large diminution of the breadth at the water-line. In existing submarines the form is not cylindrical but cigar-shaped, the diameters of circular cross-sections being gradually diminished as the extremities are approached. All cross-sections have their centers on the axis of the vessel; it therefore follows that, even in the surface condition, the crowns of the arches of cross-sections situated toward the bow and stern are actually below water. Consequently the water-line length of the vessel at her lightest draft is much less than her extreme

lows, therefore, that as the draft is increased—since both breadth and length at the water-line are diminished rapidly in submarines—there must be a considerable diminution in longitudinal stability. Reduction in water-line length is obviously the most potent cause in lessening longitudinal stability, but diminished breadth also tells heavily. These statements may be illustrated, and possibly be made more generally intelligible, by official figures for "A 8." In the surface condition at ordinary light draft, with a reserve buoyancy of 13 tons (excluding conning tower) the longitudinal stability may be expressed by the number 100. With a reserve of buoyancy of six tons, the longitudinal stability falls to 73; with three and a half tons reserve it becomes 27; and in the diving condition—with 800 pounds reserve—it is less than 7. These are striking results; it will be noted that whereas the surrender of seven tons in the reserve of buoyancy is accompanied by a reduction of about 30 per cent of the longitudinal stability existing in the surface condition, a further surrender of only two and a half tons involves a reduction amounting to 73 per cent of the original value; while the final preparation for diving with an additional surrender of rather more than three tons of buoyancy increases the loss of stability to 93 per cent. If one ton is moved through three feet longi-

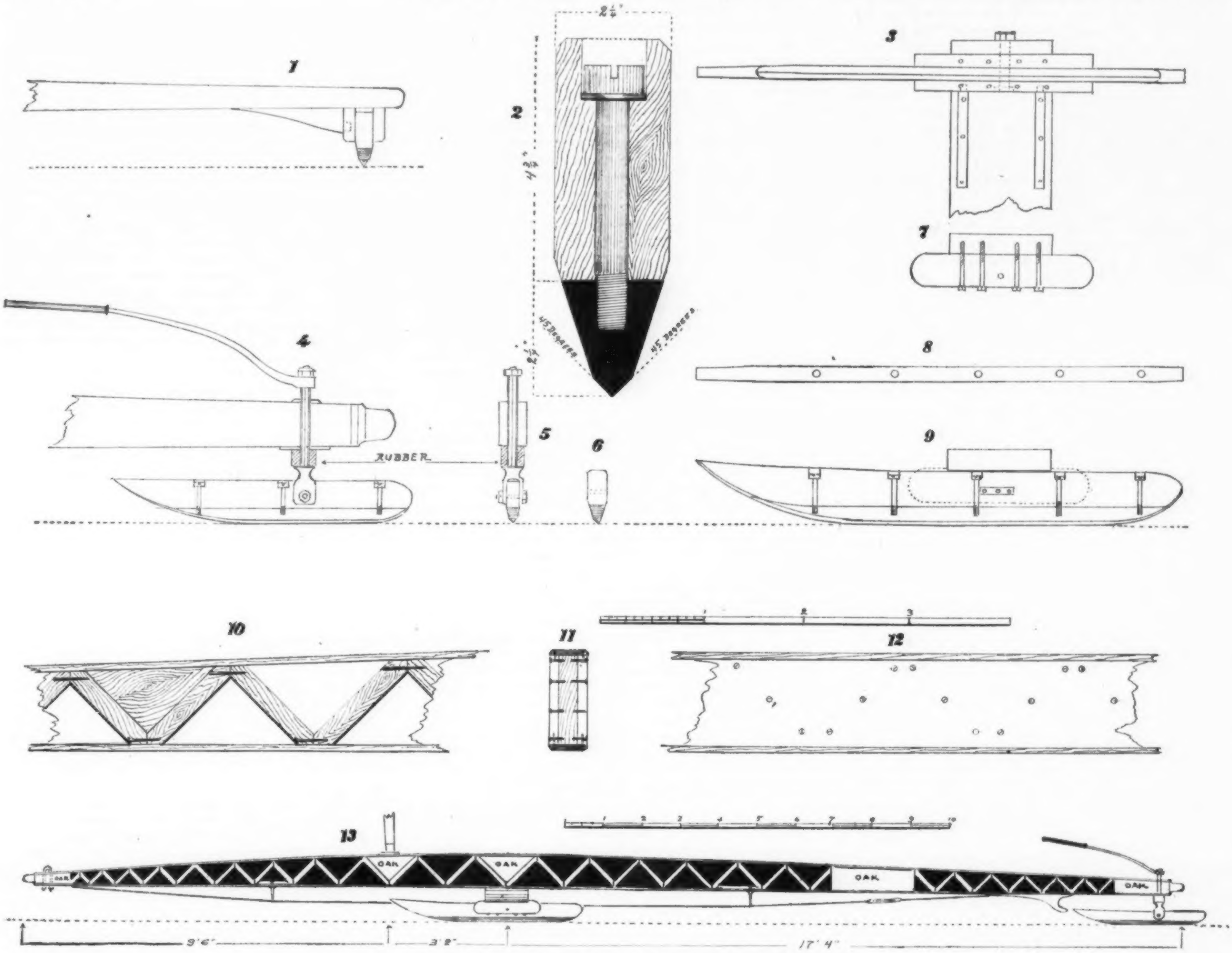


PLATE II.—DETAILS OF ICE YACHT CONSTRUCTION.

A number of these boats have been built with hollow backbones and have proved cup winners. They have been raced in gales, and are in as good condition as when first sailed.

The hull should be finished in fine sand-paper, one coat of light-colored filler, sandpapered, and two coats of the best spar varnish, the first coat to be pumice-stoned smooth. The illustration of the completed yacht made from a photograph shows clearly the new distribution of sail area arranged to secure the greatest speed and stability.

SUBMARINES.—VI.*

By Sir William H. White, K.C.B.

The "cigar shape" adopted for submarines, primarily for the purpose of securing the association of lightness with strength to resist external fluid pressure, introduces geometrical conditions which involve radical differences in stability as compared with vessels of ordinary form. Allusion has been made to the stability of submarines in previous articles, but it will be necessary to give further explanations in order that the third source of danger—the risk of sudden diving when under way at the surface—may be understood by readers unfamiliar with the subject. This explana-

* London Times Engineering Supplement. The previous installments have appeared in Supplements Nos. 1536, 1537, 1538, 1550, 1555.

length; and this water-line length diminishes rapidly as the vessel passes from the surface to the diving condition. The writer has not the facts for "A 8"; but in the case of a submarine one hundred feet in extreme length the water-line length in the surface condition was less than seventy feet, and in the diving condition it was about twenty-five feet. The water-line breadth amidships in the surface condition was 75 per cent of the extreme breadth, and in the diving condition was about 30 per cent. Every one who has seen submarines under way or has seen photographs of these vessels will readily understand the conditions described and will realize the great difference between these conditions and those for ships of ordinary form, wherein the length and breadth at the water-line change but little as the ships pass from light to load draft.

The form and area of the horizontal section of a floating vessel made by a plane coincident with the water surface—and termed the "plane of flotation"—have great influence on her stability. For present purposes longitudinal stability, i. e., the power to resist the forces tending to depress the bow and raise the stern, or *vice versa*, need only be considered. This longitudinal stability varies directly as the product of the breadth at the water-line by the cube of the length, and inversely as the volume of displacement. It fol-

tudinally in the diving condition, the trim is altered one degree, the stern being raised or depressed relatively to the bow by about two feet, whereas in the surface condition the corresponding change would only be 1-15 that amount. The absolute necessity for assigning to every man a station at which he must remain, and for avoiding changes in the longitudinal positions of weights, when a submarine is being prepared for diving, will be understood from these figures, and needs no further explanation. Lieut. Candy, in his evidence before the court martial, made statements which illustrate the extreme "tenderness," due to small longitudinal stability of submarines when prepared for diving, even in perfectly calm water. Speaking of "A 8" he said: "After the boat was trimmed (for diving) and horizontal . . . I took no more water in, but waited a minute or two before blowing (i. e., expelling the water-ballast), in order to be quite certain that the boat was horizontal, as submarines are rather inclined to oscillate when trimmed." This brief statement indicates the extreme care required in order to secure the nicety of adjustment of water-ballast when a vessel weighing over 200 tons is to be left with only 800 pounds of buoyancy and to be perfectly horizontal in trim. In the case of "A 8" on this occasion, the preparation for diving took about three-quarters of an hour, and the sea was calm, but the com-

panion vessel was prepared in about one-third of that time. When "trimmed," and lying at rest in still water, the submarine could be made to change her trim or to oscillate by the action of very small forces; and if such forces were applied suddenly or very quickly the extreme oscillatory movement might approximate to twice the permanent change of trim corresponding to the steady action of the same force. In considering the risks of submarines the possibility of sudden applications of disturbing forces must, therefore, be taken into account—such as rapid movements of men or very quick application of the helm to the horizontal rudders. The contrast between submarines and ordinary types of warships may be illustrated in another way. The longitudinal "metacentric height," which is a measure of stability, in ordinary types, varies little from light to load draft and commonly exceeds the lengths of ships by 15 to 25 per cent; in submarines, at their lightest draft the *maximum* metacentric height may be as little as one-eighth of the length, and as draft increases it falls rapidly in value.

Passing from rest to onward motion, dynamic forces begin to operate on a submarine, and greatly influence her behavior. In the surface condition the "nose" of a submarine like "A8" is under water, and as she is driven ahead by her engines the relative motion of the surrounding water develops stream-lines, which produce an altered distribution and value of the fluid pressures on the immersed portions of the hull, as compared with the statical pressures operating when the vessel is at rest. Similar changes occur in all vessels, the general tendency being toward deeper immersion and change of trim when ships are under way as compared with their condition when floating at rest. By means of model experiments and observations of the behavior of actual ships these phenomena have been investigated, and the increase of immersion and change of trim have been measured. In ships of ordinary form these changes are of little importance; and (as above explained) the longitudinal stability remains nearly constant for a considerable variation in draft. In submarines, on the contrary, each inch of immersion in passing from the surface to the diving condition is accompanied by a diminution of longitudinal stability, the rate of diminution growing rapidly with increase in draft. Consequently the effect of headway on submarines is much more serious than the corresponding effect in ordinary ships, and as speeds are increased that effect becomes more marked, increased immersion producing sensible reduction of longitudinal stability.

The wave-phenomena due to onward motion are also different in character in submarines from those of ordinary ships. In the latter, with considerable freeboard and approximately vertical sides above the water line, the wave series due to headway are maintained practically unbroken. In cigar-shaped submarines, with ends below water when at rest, onward motion produces broken water, especially forward; the vessel is partly covered by water to an extent exceeding that when she is at rest, and the stream-line motions develop pressures tending to drive the bow downward, while the rise of water on the hull diminishes longitudinal stability, and so increases the dip of the bow. It is usual to trim submarines somewhat by the stern in the surface condition, for the purpose of meeting this tendency to dip when driven ahead, and to control the trim by means of horizontal rudders. Want of care or skill in managing these rudders may cause trouble even in the surface condition; and the rapid application of considerable helm (as above explained) may cause very notable excursions in the longitudinal oscillations beyond the trim which the use of the same angle of steady helm would maintain. In the case of "A8" it was stated at the court martial that, when her reserve of buoyancy was reduced to 3½ tons, model experiments indicated that the stream-line action due to a ten-knots speed would cause the bow to dip two degrees. In such a case model experiments may not absolutely represent the behavior of the vessel; and at that time, although a model of "A8" herself was in preparation, it had not been tried. Late in July the experiments were said to be still incomplete. It would add greatly to the scientific value of these trials if a sister vessel of "A8" was tested under various conditions, being towed at different speeds, so that the results might be compared with model experiments.

In passing, it may be remarked that in the diving condition the stream-line pressures, especially on the forward end, are the active cause of submergence. The horizontal rudders are inclined downward when a submarine is to dive; this causes the bow to dip and the fluid pressures to become greater on the upper part of the vessel. The vertical component of these pressures acting downward must overpower both the small reserve of buoyancy and the vertical component of the rudder pressure (both of which act upward) before submergence can result. After submergence, suitable manipulation of the horizontal rudders enables a practically horizontal course to be maintained by careful and skilled men. On the other hand, carelessness or mistakes in management of the rudders may result in great depths being reached in a short time, with consequent danger of injury or loss; and as higher speeds are attained the danger of such accidents must become greater.

Keeping the foregoing general statements in mind, attention is directed to the circumstances attending the foundering of "A8" as detailed by her commanding officer and other witnesses. The vessel had been "trimmed" for diving with some difficulty, but on the whole satisfactorily. Some of the water-ballast tanks had been emptied; in one large tank, however, and in the auxiliary tanks water ballast had been retained, probably amounting to seven tons. The reserve of buoyancy was, therefore, about six tons (excluding conning tower) instead of 13 tons; the draft was about eight inches deeper than on previous trials, the longitudinal stability about 27 per cent less, and the vessel had never been tried at full speed at so deep a draft. After she had been under way about five minutes—during which time her speed had been increased gradually to the maximum of ten knots—Lieut. Candy observed the water to be rising round the bow, and noted that the tail flag, which was previously out of sight, had come out of water about a foot. This flag was about a foot deep, so that the stern must have lifted quite two feet, the bow being depressed correspondingly. Before starting the trim was four degrees by the stern, and it was intended to keep her at that trim during the passage. The change observed by the commanding officer indicated that as speed was increased a considerable dip of the bow and rise of the stern took place, which change Lieut. Candy attributed to the action of the horizontal rudders; he therefore sent an order to the man at the helm to keep a better look-out. As the vessel advanced the dip of the bow continued to increase gradually; eight to ten minutes from the start the water had reached the top of the superstructure forward. Still thinking that the man at the helm was responsible, Lieut. Candy sent another message to him to put the rudders up and to leave them alone. He added: "From the time I gave this message to the time I realized that the water was coming too close to the top of the conning tower I should say was less than 15 seconds;" from which statement it is obvious that, at the moment, the bow must have been plunging rapidly, since the top of the conning tower was about ten feet above water when the vessel was at rest. Up to this stage no water had entered the hatchway, but the risk was great, and Lieut. Candy decided to give the signal to stop the engine. The hatchway was necessarily open while the gasoline engine was working. If it had been closed and no water had entered, there is good reason for believing that "A8" would have dived below the surface; and if headway had been maintained she would probably have reached a considerable depth, although she might have regained the surface. Having regard to all these facts it cannot be admitted that Capt. Bacon was justified in classing the foundering of "A8" with accidents to other vessels, described in previous articles, whose loss was due to the entry of water through open hatchways. The final catastrophe to "A8" resulted, no doubt, from an inflow through the conning tower hatch, but, before the inrush of water began, other causes had produced the change of trim and final rapid plunge of the bow which brought the hatch down to the water-level from its original elevation of about ten feet. Had not these causes been operative "A8" would have remained afloat. Her foundering indicates clearly the danger of sudden and unexpected diving by submarines under certain conditions of draft and trim, if they are driven or towed at considerable speeds. Other instances are on record of similar behavior by foreign submarines, fortunately not attended by serious loss of life. In France a submarine which was in tow of a tug is reported to have dived suddenly and unexpectedly; in the United States submarines are reported to have plunged to considerable depths without previous indication of such a tendency. Whether improper management of the rudders in "A8" was partly or chiefly to blame for the initial dip of the bow can never be known. The diver found the rudders "hard up" in the position ordered by Lieut. Candy immediately before the final plunge. Evidence of their previous handling is wanting beyond the statement that the man in charge was capable and experienced, had definite orders to maintain the trim of four degrees by the stern and was reminded of that order five minutes after the start. It is, however, certain that a gradual sinkage of the bow took place, and that the fluid pressures due to stream-line motions in water surrounding the vessel had much, if not most, to do with the great change of trim and the final rapid plunge. At the court martial it was stated that additional experiments were being made by the Admiralty on this subject, which does not admit of exact mathematical treatment apart from experiment. Capt. Bacon gave further information when his paper was read, explaining that unforeseen difficulties had arisen in the model experiments, and that these difficulties were receiving careful consideration. This is entirely satisfactory so far as it goes; but as the matter is of great importance to naval architects and of much scientific interest to all concerned with problems of propulsion and fluid resistance, it may be hoped that the general conclusions from the experimental results will be published hereafter by the Admiralty. Such a publication would involve nothing of a character that should be kept secret in the public interest, and would advance the knowledge of hydrodynamics.

The effects of the preservatives upon the functions of the body have been studied in detail. It is admitted that there is a necessity for mineral substances in the blood, as they are essential to the functional activity of the various organs of the body, irrespective of any part they may take in direct nutrition. The necessity, for example, of saline solutions in the blood is known to every physiologist, but it is evident that these saline solutions can be derived from materials of common occurrence and naturally found in food products, or usually added thereto as condiments, such as common salt.

HOW OUR SENSES DECEIVE US.

By Dr. Andrew Wilson, F.R.S.E., etc.

If we place a pea between the middle and fore fingers, the outer side of the forefinger and the inner side of the middle finger being respectively in contact with the pea, everybody knows that the sense of touch will convey the information that only one pea is being dealt with. If now we cross the fingers, and place the pea between them, and thus reverse the finger-surfaces which are in contact with it, by the same "avenue of sense" we get the impression that we touch two peas. I am not taking into account any connection which may be brought to bear on the experiment by the sense of sight, but simply regarding the information which that of touch alone conveys to us. If we make the experiment blindfolded, or with our eyes shut, the conditions for our deception will be rendered all the more successful. If we cross the fingers and rub a marble between them so that the marble will come in contact with the tips of both fingers, we receive an impression of two marbles. If we cross the fingers and pass them over the tip of the nose, we may even succeed in conveying to the mind the somewhat ludicrous notion that we have a double organ of smell. This in itself is a somewhat curious, if simple, experiment. It opens up an extremely interesting field of speculation concerning the trustworthiness of our senses. It also deals with the question of the extent to which we can trust these "gateways of knowledge" to convey to us accurate accounts of the impressions of the outer world. Needless to remark, our knowledge of that world is gained through the media of the sense-organs which, to the number of five, we certainly possess, although there are trustworthy considerations enough at hand to suggest that this number does not exhaust the whole array of our avenues of information.

In ordinary life we are accustomed to trust implicitly to the evidence which our senses place at the disposal of the brain regarding the world we live in and our own relations to it. It must not be forgotten, of course, that when we speak of hearing, seeing, tasting, and so forth, we are in reality describing the work not of the senses so much as that of the brain itself. We do not really see with our eyes or hear by means of our ears. Eyes and ears are, after all, only "gateways of knowledge," as George Wilson long ago aptly styled them. They receive impressions in the shape of light-waves and sound-waves respectively from the outer world, and prepare and adjust these impressions for transmission to the special centers in the brain destined to receive them. The sense-organ is simply an under official which performs its duty in a somewhat mechanical fashion and transmits the result of its work to the sub-office in the brain which presides over its destinies. Even here we do not reach the end of our tether in respect of the senses and their ways and works, for the sub-office has no power to institute comparisons or to pronounce judgment on what is seen or heard. These important duties are exercised by the head-office represented by another, the highest, part of the brain, where our consciousness—that is, the appreciation of the knowledge of what we see and hear, and what we are and what we are doing—is exercised.

Yet in ordinary life we have become so accustomed to regard the senses as our courts of appeal in all intellectual difficulties that the phrase the "evidence of our senses" has become almost classic in the common vernacular. However, so far from such evidence being always trustworthy or reliable, science teaches us that we are singularly liable to find our sense-impressions have played us false by reason of the infirmities which mark our physical and mental disposition at large. When a man says "I saw this" or "I heard that," we have no doubt that he did see or hear something; but the interpretation of what he did see and hear may be totally at fault, and for the erroneous impressions to which he may give vent his senses may occasionally be responsible, just as his brain may be credited with occasional lapses in its work of interpretation.

I was talking to a distinguished lawyer some time ago, and remarked on the very variable and often contradictory character of the testimony one hears in a court of law. I added that it was a source of wonder to me that prosecutions for perjury were not more frequently represented in our legal procedure. I instanced a case in which, say, half a dozen persons all witnessed the same occurrence, with the result that each of the half-dozen might, and probably would, give an entirely different account of what they saw when examined in the witness-box. My friend quietly remarked that he supposed I was acquainted with the relative nature of most things in this world, and added that in the matter of evidence every lawyer knew the variations which were certain to be forthcoming in testimony of the kind to which I had referred. Each of the witnesses, it is true, saw the same series of events; but each of the six gave his own interpretation of these events. His testimony, depending on the nature of his sense-impressions, my legal friend urged, is almost certain to vary from that of his neighbors to a greater or less degree. It is here really not a question of actual false testimony which the judge has to face, but merely an attempt to collate and bring into line the different accounts of seeing things and the different impressions originated and conveyed by what was seen by the witnesses. The judge endeavors to strike a happy mean, and to arrive in this way at a fair and reasonable conclusion regarding the sequence or nature of the events under discussion.

In the ordinary operations of life, doubtless the

senses of the healthy individual serve him fairly well, and the organs of one sense can often be corrected by an appeal to other senses. Our experiments with the fingers showed, for instance, that the sense of sight is corrective of the deluded sense of touch. There is a field of inquiry which, however, one cannot touch upon here, wherein it might be shown that errors of judgment occasionally arise from the faulty operation of the brain itself. I have already hinted as much, and every conjurer offers a practical illustration of such errors on our part when we see him apparently accomplish what we know to be physical impossibilities. The man who mistakes a shadow for the substance, and sees a white-robed specter where there is only a peculiar moonlight effect, is the subject of the erroneous interpretation of what he sees. This is what is called an "illusion," and the brain, we may note, is much more at fault here than the eye. But even in our sober senses, apart from illusions of the kind to which I have referred, our senses may play us many fantastic tricks and lead us toward conclusions which may be highly difficult indeed of correction from the side of our high court of appeal in the shape of the brain judgments themselves. The case I quoted of the fingers and the pea illustrates this result in a marked way. It teaches us that our sensations depend very much, for one thing, on the mere matter of habit. We are not accustomed to touch objects with our fingers crossed. In the ordinary exercise of the sense of touch we gain our information in straight pathways, so to speak. The ends of our nerves come in contact indirectly, or through the outer skin, with the object touched, and a message is consequently sent along certain nerve fibers upward through the medium of the spinal cord and onward to the touch-centers or suboffice in the brain itself. This is all plain sailing enough; but when we alter, as we do, the relative position which our fingers occupy in ordinary life, and cross them, the messages which reach the brain do so in a fashion which that organ is unable properly to interpret. We appear to possess what has been called a field of touch composed of a great many nerve-ends, and custom and habit induces in us particular modes of sensation as the result of the exercise of special nerves. If we disturb the natural position of these nerve-ends with reference to each other, we can only receive confused and erroneous pieces of intelligence from their messages. This view of matters may forcibly impress upon us the fact that it is really the brain that interprets, and that it is not the mere sense-organ receiving the impression which is at fault. But in justice to the brain, we must bear in mind that every other organ of the body has its own ways of working, and must conform very largely to these ways if its duties are to be satisfactorily performed at all.

The sense of touch is also responsible for sundry other curious bits of byplay. It is a familiar fact of surgery that when a man has had his leg amputated, say below the knee, he will complain of pain, not in the stump, but in the toes of the missing limb. In one case the patient felt very strongly the pain of a troublesome corn which had decorated one of the toes of his amputated foot. In another case, an American one, the patient remarked to his doctor, "If I should say I am more sure of the leg which isn't than the one which is, I guess I should be about correct." Here again we explain the deception of the senses on the principle that the impressions which were wont to be received from the missing limb passed in certain definite nerve-channels to an equally definite area in the brain. The impression is transmitted from the end of the shortened nerve which received them from the whole leg itself, and the brain-center, we may presume, has not acquired the power of accurately localizing them in the stump. Precisely the same case is illustrated by a patient who has had a defective nose restored by transferring a flap of skin from the forehead—in which case the flap takes root, as it were, in its new situation—and who experiences a feeling as if his forehead were being touched when the nose is tickled. It takes a certain time for the brain to become used to discriminate between mental messages coming from an unaccustomed source and the old impressions which the now misplaced nerves were wont to convey to it.

The sense of sight itself is rich in the matter of deceptions. We can record many instances of erroneous impressions liable to be conveyed to us by our eyes, and of the curious optical phases which may arise to puzzle and befog our most careful judgments. Take the case of a face represented in a portrait. The eyes appear to follow the spectator from whatever direction the picture is viewed. This is an illusion, no doubt; but it is one which arises not from the eye alone. The brain plays a certain part here in assisting the deception, as Sir David Brewster long ago demonstrated. The painting is, of course, done on a flat surface, and presents to the eye of the spectator a front view of the object only, and this in whatever position he may stand. The eye of a real person, on the other hand, is thrown into relief. If we move to one side we see the side of the eyeball and miss seeing as much of the pupil as when the eye is kept steadily to the front. But as we gaze on the picture we are presented from any point of view with all the elements of the eye regarded from the brain, and the brain simply translates this continuous front-view into the illusion of the moving eye. We are so accustomed to regard the eye in a picture as looking directly at us that we fail to make allowance for the relief which would inevitably arise if the eye were a real one. There is a picture in which the muzzle of a gun is so trained that it appears to point directly at the spectator in whichever position he may stand. Here the only view of the painting is that which we should see if we directly faced it. The brain makes no allowance, in other words, for the flatness of the painting and for the persistent front-view it places before the spectator.

Physiologists are accustomed to give certain well-known diagrams by way of demonstrating the deceptions the sense of sight may practise upon us. For instance, it is a familiar fact that if we outline a straight line by a dot at each end, divide it into equal parts, and then further divide one of its halves equally by a series of dots, leaving the other half blank, we receive the impression that the divided half of the line is longer than the undivided half. Here the work of estimating the relative length of the dotted half is accomplished by a series of impressions, while the eye takes in the undivided half in one impression. Similarly, if a series of straight lines be drawn vertically, and a similar series horizontally, and a square be situated side by side, with its sides exactly equal to the lines in length, we at once acquire an erroneous notion of the relative proportion of these figures. The vertical lines will give us the idea of greatest breadth and the horizontal lines that of greatest height, while the square will appear smallest of all. Yet on measurement all three exactly cover the same area. No doubt in this case the brain is the real seat of the erroneous judgment, for it is difficult to explain how the eye itself can be deceived. Impressions made on the organ of sight are doubtless really of the same size throughout; but the impression conveyed is imperfectly translated.

Another well-known fact is that in which a thin line has arrow-headed terminals, and another of precisely the same length has its terminals reversed. The reversed terminals give the impression of far greater length of their line, owing to the divergence of the ends and of the optical axes. The apparent shortness of the other line is due to the converging of its arrow-shaped ends conveying an impression of limitation. "Zöllner's lines" form yet another interesting study in sense deception. Oblique lines drawn with smaller lines crossing them are in reality strictly parallel, but appear to exhibit convergence. Our eyes, in fact, tend to separate out the short crossing lines, with the result that false or implied impression of their meeting makes us suppose the long lines are not parallel. Allied to the case of "Zöllner's lines" is another familiar figure illusion where a thin line is made to intercept a thick one in an oblique fashion. If now below the thick line another line parallel to the intercepting one is drawn, we get an illusion that the second line below the thick one is a continuation of the single top line. The reverse is, of course, true; for here, the interruption of the field of vision caused by the thick line puzzles the judgment and causes the illusion of continuity in the wrong direction.

The unconscious application of some of the principles thus illustrated in our ways of seeing things to such matters as even dress may be readily illustrated. For instance, on the principle seen in the vertical and horizontal parallel lines, we find that people who are short and stout will frequently dress in materials that exhibit cross or horizontal stripes. On the principle that vertical lines give the appearance of greatest breadth, the stout-bodied person will do well to avoid choosing a pattern in which the stripes run in this direction. That comparisons of height are strictly relative matters is demonstrated when we see a very big person alongside an undersized one. Here the law of contrast applies; the former appears taller than he really is by contrast. So all our comprehension of the size, say, of the moon will be materially affected according to its position. If we happen to see the Queen of Night in close contrast with trees or other near objects, its size is apparently increased. At the zenith, wanting comparison, size is diminished. The farness or nearness of objects is also much affected by the circumstances under which our vision is exercised. A fog will cause an ordinary-sized person to look like a giant. He is apparently farther away than he really is, with the result that in our mind we make an unconscious comparison of his apparent size with what we know or think to be his natural stature when he is near to us. On the like principle of being deluded by distance, we think a hill seen on a hazy morning to be a big mountain; whereas, conversely, in very clear air the eminence diminishes in size. We regard it as nearer to us than it really is; and our judgment regarding its size is affected by the erroneous work of the eye. When we speak of a telescope "bringing things nearer to us," we must regard this expression as amounting simply to a figure of speech. The object we gaze at remains where it was. If we look through the wrong end of a telescope or opera-glass we at once gain the impression of an opposite kind, that of the far-away location of an object which may really be relatively close to us.

Certain illusions of the senses may, of course, depend on physical laws and conditions, the effects of which we have to correct by an appeal to our ordinary powers of judgment. A stick or an oar placed half in clear water looks to us as if it were broken, this appearance being due to the bending of the light-waves. In the case of moving objects, our senses find a very profitable sphere of work in the way of deceiving us. If we look at a moving body we may discern its motion according to one or other of two principles or actions. For instance, if the eye follows the movements, we require to move the eyeballs in their sockets by means of the muscles provided for that purpose. If we keep the eye perfectly still we may note the object move because its image crosses the retina, which is the eye's sensitive plate whereon things seen are duly impressed. If now we suppose that our eyes move and the object gazed at remains stationary, we may receive impressions of a similar kind; and we have also to take into account movements of our own, either in the same direction as the object or in the opposite direction to that in which the thing seen is moving. Thus, if we are actually moving, as when we are seated in a train, and the fact that we are speeding along passes away from us into the dim and misty regions of half-consciousness, we gain an impression that the telegraph-poles and everything else are speeding past us in rapid movement. So also when a train running in the same direction passes us, say at an almost equal speed to our own, the impression conveyed is one of a slow pace in the overtaking train, although it may be traveling at an express speed. The train which passes us in the opposite direction, on the other hand, is seen to fly at lightning pace, because, as in the case of the telegraph-poles, we do not readily realize that we are moving, but regard ourselves unconsciously as practically at rest. There is another common illusion in railway traveling remarked by everybody. When a train is standing alongside ours, and it begins to move, the illusion is borne in upon us at first that it is our train which is in motion. Here the idea comes into play which assumes that our surroundings are stationary and that our train represents the only movable part of them. There is a tacit expectation of the mind here which constitutes the basis of the deception, and this of course is only corrected by our noting a really fixed object, such as the platform next which our train is at rest.

A more complicated illusion of sight, as regards its origin at least, is that experienced when we watch the sea from a steamer's deck. The feeling slowly dawns upon us that it is the waves which are moving in the opposite direction to that of the steamer's course, while the vessel itself appears to be stationary. Some way beyond the steamer, we are conscious that the water's movement is lessened greatly, till practically it appears to be itself still and immovable. If now the eyes be turned to the deck, we appear to witness a forward movement of the part next us, while beyond this part the deck seems stationary. Here it would appear that the retina is affected by light-rays coming from the water with varying rates of motion. When we turn our eyes to the deck, where all is fixed, the persistence of the impressions gained from the sea with their different rates of motion transfers to the solid steamer similar movements.

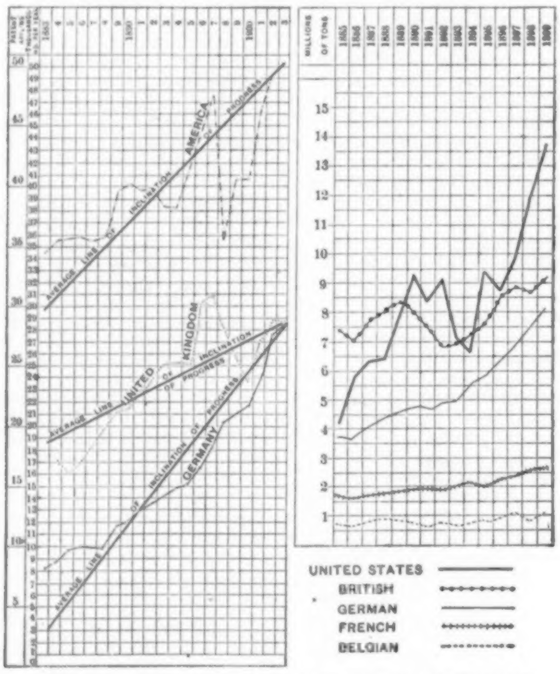
The apparatus once so popular and known by the name of the "wheel of life" or "zoëtrope," in which a number of figures printed on a paper roll was viewed from the slits in the side of a revolving drum, must have been familiar to most readers. The figures appeared to be in active motion, and the movements, say, of a jumping horse or of boys playing leap-frog were in each case eventually reproduced. Here we have to deal, as in the preceding instance, with the persistence of retinal impressions, or, in other words, the period of duration of the images which are rapidly received by the eye's sensitive plate. A good example of a simple impression of this kind is afforded when we look at the sun. If the eye is then turned away from the brilliant light and focused on a dark surface we fail to see anything at first, but soon become conscious of a brilliant spot called the "after-image" of the orb of day. This image we may even see when the eyes are shut, because, of course, that proceeding does not interfere with the action of the retina at the back of the eye where the "after-image" is for the time being in full glow. We note that the image persists for some time after the actual object which gave it birth has been withdrawn from our vision. The boy who lights the end of a stick, and by whirling it rapidly round conveys to us the idea of a circle of fire, has illustrated for us practically the same illusion. Each movement of the lighted end of the stick giving an impression is practically succeeded so quickly by another impression that we experience a sense of a continuous line of fire in place of noting the actual passage of the one burning point through space.

In the latest development of the "wheel of life" idea, seen in the cinematograph and like exhibitions, we have presented another example of the persistent retinal impressions. Here we see a body of soldiers marching, a fire-engine turned out, waves rolling on the beach, and other scenes all depicted exactly as they occur in nature. The series of photographs taken of these events is rapidly passed before us, so rapidly indeed that neither the eye nor the judgment has the power of separating the individual photographs, and the illusion of a series of continuous movements is thus complete. It is the principle of the boy's burning stick and the zoëtrope wonderfully elaborated by aid of the art of instantaneous photography. These examples may suffice to show how very imperfect, after all, the judgments which rule our actions may be regarded, dependent as they are on the testimony of senses which themselves are liable to transmit to the brain-centers erroneous impressions of the things and objects of the outer world. It is often said that in respect of certain senses, man is less perfectly endowed than are many of the lower animals. He may not possess an accurate sense of smell such as is the possession of certain dogs, and he may not be endowed with the eyesight of many birds. His sense capacities must be regarded as limited when compared with those exhibited by some of his poorer relations. But, taking man's senses all round, they discharge their duties with a fair amount of accuracy, and with sufficient exactitude to enable the normal human to guide his footsteps aright and to avoid the mental pitfalls that may threaten to engulf him. Happily for us, the healthy judgment is on the whole able and sufficient

for the most part to correct even those erroneous impressions which occasionally make their appearance at the gateway of reason itself.—Chambers's Journal.

INVENTION IN GREAT BRITAIN, GERMANY, AND AMERICA.

In a discussion in the British trade papers concerning the lack of encouragement of the British inventor, as compared with his American and German rivals, the proposition was made by Mr. B. H. Thwaite that the true index of any nation's industrial and commercial position was not that of the axiom of Disraeli—the state of the chemical industry—but the condition of the iron and steel industry. Mr. Thwaite thought there was also another index almost as valuable, namely, the degree of activity of a nation's inventive faculty, represented by the numerical proportion of applicants for patents. The charts here given, prepared by Mr. Thwaite, show the progress of inventive activity in America, the United Kingdom, and Germany during the twenty years ending 1903, and the comparative progress of the five great iron producing countries in the production of pig iron from 1885 to 1899. From the former it will be seen that the rate of increase of inventive activity of Germany has been slightly more rapid than that of the United States, with Great Britain left some distance in the rear. The attitude of the British patent office is one to discourage many inventors. For instance, under recent legislation the British inventor is compelled to subdivide his claims so as to cause him to apply for a number of patents in place of one. Taking out patents is a very expensive matter in Great Britain, and it is claimed by many that the cost under the new act referred to will be greatly increased. Moreover, the granting of a British patent does not even now insure validity. The German inventor, on the other hand, is stimulated to enterprise by the German mercantile banking system, by which selected inventions of promise are developed and commercially introduced under the best conditions to secure success.—Machinery.



CHARTS SHOWING COMPARATIVE INVENTIVE ACTIVITY AND PRODUCTION OF PIG IRON.

FIGURES WHICH FORM UPON THE SURFACE OF CRYSTALS WHEN THEY ARE DISSOLVED IN A LIQUID.

When a crystalline surface is exposed to the dissolving action of a liquid, it becomes covered with more or less regular figures. We are already acquainted with the *corrosion figures*, which are determined by the nature of the crystallographic face. I already showed that they are quite distinct from another group of cavities which are formed on the plane of the face, to which I gave the name of *convection striae*. The latter are in the form of parallel lines or streaks on the crystal surface, while the corrosion figures are formed of spots of different shapes distributed over the surface. The convection striae appear when the crystal is dissolved in the liquid at a constant rate. The currents which are formed in the liquid are thus made to engrave their trace upon the surface of the crystal. The rate at which the crystal is dissolved varies with the direction of the surface as regards the force of gravity and the character of the streaks thus varies in the same way. For instance, when the horizontal face of a crystal is placed in the liquid so as to be dissolved, and in an excess of liquid, we find that a series of hexagonal cellules are produced. On the contrary, if the crystal is given another direction so that the under surface is inclined from the horizontal position we observe a series of parallel streaks on the face of the crystal. Besides, the nature of the crystal's face seems to have little or no influence on the form of the striae, and we can thus obtain parallel streaks upon the three principal faces of a sulphate of copper crystal by placing each face in the same position with regard to the liquid. But when the position is changed, the form of the streaks varies also.

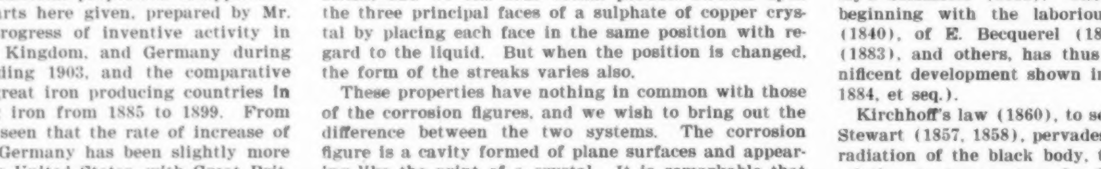
These properties have nothing in common with those of the corrosion figures, and we wish to bring out the difference between the two systems. The corrosion figure is a cavity formed of plane surfaces and appearing like the print of a crystal. It is remarkable that these figures resemble each other in character and direction on a given face of the crystal whatever may be the inclination of the latter. We find a very marked difference in the two kinds of figures, which may be *résumé*d as follows:

The corrosion figures appear as soon as the crystal commences to dissolve and when the solution is at a variable rate. Their form and direction are constant on a given face and vary with its nature (that is, its crystallographic nature) but not with the position of the surface with regard to the liquid. Their method of appearing and their growth is unknown, and seems to have no rule. Their dimensions are quite variable on the same face, on an average from 1-200th to 1 millimeter diameter in the case of pure water.

The convection streaks, on the contrary, appear as follows. They are seen when the crystal is dissolved at a permanent rate, and only some time after the beginning of the attack. Their form and direction vary only with the position of the face and not with its crystallographic nature. As to the method of appearing and the dimensions, these depend upon the rate of solution in the liquid. The size becomes fixed as soon as the dissolving rate becomes permanent, and they have the same value on all parts of the face, in mean, one-half to 1 millimeter diameter with water.

These differences will be easily observed from the accompanying photographs of some samples of chrome alum after their attack by water. On the samples *A* and *B* we see the corrosion figures and their irregular variation during the action of the liquid. The sample, *C*, shows the convection striae, which here appear quite regular. The latter are determined by the permanent rate of solution. On the sample, *D*, the striae are also seen, but here they are not so well defined.

The author wished to find the influence of the strength of the liquid upon the speed at which the crystal is dissolved. The speed depends on different conditions. Some of these can easily be realized, such as the temperature and the strength of the liquid. Others, like the purity and micro-structure of the solid, cannot easily be reproduced identically. But if we find that after a trial, the streaks are very uniform, we may conclude that the *ensemble* of the conditions is well determined. In such cases the speed of the normal wear of a face (when in the same position) has a precise signification, without considering any other effects in the liquid. The author carries out the experiments as follows: The crystal is covered with a layer of paraffin which protects all but the surface in question. Thus prepared, the solid is suspended under the plate of a balance by means of a fine thread of paraffined cotton, and is then placed in the liquid. The whole is balanced at once and it only remains to measure the time intervals which correspond to a given loss of weight as the crystal is dissolved. The losses are compensated by adding weights so as to bring the pointer of the balance back to zero. We thus know the amount which is dissolved in a given time and consequently the normal speed of solution. M. Schur thus finds that with sulphate of copper crystals the normal speed remains the same, whatever face of the crystal may be attacked, provided it has the same position in the liquid. This result is not surprising, as we have already seen that in such cases the streaks are always the same. Therefore the speed of solution, other things being equal, depends only upon the strength of the liquid. He finds also that the speed at which the crystal is dissolved in the liquid is proportional to the difference of the logarithms of the maximum and the given strength of the liquid. This law holds good in most cases. It was verified with sulphate of copper and with the alums, especially with chrome alum.—Paper read before the Société de Physique by Prof. J. Schur.



No. 1 A. No. 2 A. No. 3 B. No. 4 B. No. 5 B. No. 6 C. No. 7 D.

1 A. Corrosion figures obtained after 4 seconds attack by the liquid. 2 A. Corrosion figures obtained after 6 seconds attack. 3 B. Figures after 2 seconds attack. 4 B. After 4 seconds. 5 B. After 6 seconds. These five figures are magnified ten diameters. 6 C. Convection striæ obtained after 1 minute on a face of the crystal inclined downward at 45 degrees. 7 D. Convection striæ after 1 minute on a face very slightly inclined. These two figures are ⅝ the original size. The above figures were made from the positive plates, and thus the cavities in the crystal appear as projections and *vice versa*.

CORROSION FIGURES AND CONVECTION STRIÆ OF CHROME ALUM.

RADIATION.

Our knowledge of the radiation of heat, diathermacy, thermocrosis, was promoted by the perfection which the thermopile reached in the hands of Melloni (1835-53). These and other researches set at rest forever all questions relating to the identity of heat and light. The subject was, however, destined to attain a much higher order of precision with the invention of Langley's bolometer (1881). The survey of heat spectra, beginning with the laborious attempts of Herschel (1840), of E. Becquerel (1843, 1870), H. Becquerel (1883), and others, has thus culminated in the magnificent development shown in Langley's charts (1883, 1884, et seq.).

Kirchhoff's law (1860), to some extent anticipated by Stewart (1857, 1858), pervades the whole subject. The radiation of the black body, tentatively formulated in relation to temperature by Stefan (1879) and more rigorously by Boltzmann (1884), has furnished the savants of the Reichsanstalt with means for the development of a new pyrometry whose upper limit is not in sight.

Among curious inventions Crookes's radiometer (1874) and Bell's photophone may be cited. The adaptation of the former in case of high exhaustion to the actual measurement of Maxwell's (1873) light pressure by Lebedew (1901) and Nichols and Hull (1903) is of quite recent history.

The first estimate of the important constant of solar radiation at the earth was made by Pouillet (1838); but other pyrheliometric methods have since been devised by Langley (1884) and more recently by Angström (1886, et seq.).

NOTE ON FILLING A BAROMETER TUBE.

By N. F. Smith, Olivet College, Olivet, Mich.

The problem of successfully filling a barometer tube with mercury is one which has caused difficulty to many teachers, and the following method, which has been successfully used many times, may be found helpful.

The tube, about eighty centimeters long and at least six millimeters in diameter, is sealed at one end and then placed in a vertical gas pipe an inch or more in diameter provided with a cap or plug at the lower end. The gas pipe is then filled with sand, leaving the barometer tube projecting about an inch from its cen-

ter. A short piece of large glass tubing is fitted to the upper end of the barometer tube with a rubber stopper. Pure mercury is now poured into the barometer tube and allowed to stand at a height of an inch or more in the large tube at the top. Four or five Bunsen burners are clamped at various heights beside the gas pipe and the whole thing heated till the mercury has boiled for some minutes. A piece of iron wire worked up and down in the tube aids in removing the air bubbles. After the whole apparatus has cooled the tube may be removed and inserted in the usual manner. The height of the mercury in the tube will be found to differ very little from the reading of the standard barometer.—School Science and Mathematics.

MOSS DWELLERS.

By PROF. RICHTERS.

THE fauna of moss constitutes a very interesting society of diminutive, often microscopic creatures, which from their smallness escape the eye of the casual observer and of which very few persons have any knowledge, for comparatively little attention has been paid, even by naturalists, to these little animals. The study of butterflies and beetles has fascinated thousands, the fauna of the ocean, streams and ponds are objects of diligent investigation, but few have given a glance to the moss dwellers.

The reader who wishes to study this little world with his own eyes is advised to select a very thin layer of soft moss, stripped from the sunny side of a rock or a tree, as the cushions of coarse ground-moss are much less densely populated. Under the thin layer of moss, and attached to it, there is usually a brownish black, peat-like layer, more or less mingled with mineral dust. This layer is also inhabited and hence it should not be detached from the moss. It is by no means necessary to use fresh material for observation. It is even preferable, for reasons given below, to allow the moss to dry, for the moss dwellers, after remaining dry and apparently lifeless for months, may be restored to life by the application of water. This remarkable peculiarity appears necessary, and therefore less astounding, when we think of the fierce, desiccating solar heat to which moss growing on walls and bowlders may be exposed day after day. Creatures that live in such conditions *must* be so organized that they can adapt themselves to extreme variations in temperature and moisture. In December, 1904, I examined some moss that was gathered in Spitzbergen in August, 1903, and had lain in my warm laboratory, quite dry, for fifteen months—the greatest possible change from the long cold winters and the damp air of Spitzbergen. The moss contained large numbers of "bear animalcules" (*Macrobiotus coronifer*), all of which were brought back to life within half an hour by wetting and shaking. The promptness of the resurrection excludes the possibility of the observed living creatures having been, then and there, hatched from the egg.

The dried moss, when wanted for examination, is plucked into very small pieces and, together with the dust that is thus separated, is mixed with water in a glass, stirred carefully and allowed to stand from a quarter of an hour to an hour, according to the degree of desiccation. Most of the moss rises to the surface and can be skimmed off. When the sediment, consisting of the animal moss dwellers, together with vegetable and mineral particles, has settled to the bottom the clear water is poured off. A few drops of the residuum, diluted if necessary and spread over a microscope slide, presents, with a magnification of thirty diameters, a picture resembling Fig. 2. Of course, one must not expect to find twenty different species in the field of view. In some cases the moss dwellers are few, in others very abundant. From a piece of the common forest moss, *Hypnum cupressiforme*, from the Taunus Mountains, one centimeter square and a third of a centimeter thick, I obtained 50 bear animalcules. In a quarter of a gramme of dried moss from Spitzbergen I found 121 bear animalcules, belonging to four different species, and in moss taken from an oak near Frankfort I found literally countless numbers of *Difflugia globulosa*.

The moss dwellers belong to various groups of protozoa, worms and arthropoda.

The lowest forms of life are the amœbæ (1, Fig. 2). These terrestrial amœbæ do not, like their cousins of the ponds, adhere closely to supports and creep over them. In form and translucency resembling grains of sharp sand, they move along slowly, absorbing vegetable particles, bear and wheel animalcules (*rotifera*), and everything else edible that falls in their way. It is a strange sight to see a highly organized creature fall a victim to such a lump of protoplasm. Is the gelatinous amœba devoured, in turn, by some other moss dweller? Very likely, for most of its relations are furnished with armor which protects them from some enemies, at least. One protozoon, *Difflugia*, (3) builds its house of fine sand; while *Nebela* (6), and *Euglypha* (5) secrete little scales. In *Arcella* (2) the scales are united to form a chitin-like structure, shaped like the bell of a medusa, or sea-nettle, from which protrude portions of the protoplasm which serve as organs of locomotion and are therefore called pseudopodia, or false feet.

Far more highly organized are the widely distributed terrestrial nematodes, tiny worms, nearly akin to trichinæ and thread worms. To the layman all look alike, differing only in length and thickness, and zoologists have expended much labor on the study and classification of these creatures.

To the worms belong also the rotifera or wheel animalcules (7) which swarm in every pond, and are rarely lacking in moss. In young growths they and the nematodes are always the first colonists. They are especially abundant in some specimens of liverwort (*Frullania*), the cap-shaped leaves of which form excellent lurking places. Often four or five specimens of *Callidina symbiotica* may be found under a single leaf-cap, either entirely sheltered or extending their bodies and drawing in, by the action of their "wheels," currents of water laden with decaying vegetable matter. Perhaps the excrement of the wheel animalcules is of use to the plant. If so, plant and animal form one of those partnerships for mutual benefit to which the term symbiosis is applied.

Among the arthropoda we find the creatures that

FIG. 1.—A PIECE OF MOSS TURF.

are peculiarly characteristic of the moss fauna—the very diversified mites called oribatids (10), and the bear animalcules or tardigrades (13, 14, 16, 17, 18).

The former occur also on leaves, both growing and fallen, and there are one known fresh water and two marine species of bear animalcules, but most of these animals are true moss dwellers. That the very interesting bear animalcules have been hitherto almost entirely neglected by zoologists is due, in my opinion, to the fact that so little attention has been given to their natural habitat, moss. According to most writers they live in roof gutters. On what? Tin, zinc or street dust? They are occasionally found in gutters, to which, probably, the rain has washed them from moss-grown or thatched roofs.

Their principal food is chlorophyl, which they extract with their sharp probes from the moss leaves. Their stomachs are almost always found full of half digested chlorophyl. Greeff asserts that he has often found, also, the mandibles of wheel animalcules, but a bear animalcule is rarely seen to attack a wheel animalcule.

The bear animalcules, which resemble pigs or armadilloes even more than bears, are very curious creatures. Most of them are as transparent as glass, so that the whole structure of the living animal can be seen under the microscope. When dried and then moistened they remain, if not disturbed, in an apparently lifeless state in which they can be studied to the best advantage, as they are motionless and yet alive. Shaking or pressure promptly restores their activity, in many cases.

Their eggs are particularly interesting. They are usually smooth and oval and are inclosed in the entire cast skin of the animal, which, as it carries with it all the claws, readily attaches itself to any object. These egg sacks (15) contain from 2 to 30 eggs. Many species of *Macrobiotus*, however, deposit uncovered eggs, generally spherical and provided with delicate and beautiful anchor appendages, which prevent them from being washed away by rain. The eggs of *M. antarcticus* have no anchors, but a glutinous coating which serves the same purpose.

Tiny crabs are also found in moss, even in the most unlikely places. *Ophiocamptus muscicola* (9) which I first discovered in Taunus moss, I found afterward in moss from a lofty cliff in the Sauertal, remote from ponds and water courses. Crabs, however, are evidently newcomers in the moss fauna, for they have not become sufficiently well adapted to their habitat to survive long drying, and in winter they seek warmer quarters, while the bear and wheel animalcules calmly submit to freezing.

Larvae of small gnats and a most fantastic millipede, three or four millimeters long, *Polyxenus lagurus*, are also common in the moss of German forests.

Of many moss dwelling protozoa, including *Arcella vulgaris*, *Difflugia globulosa*, *D. constricta*, *Assulina seminulum*, *Euglypha collaris*, etc., we already know that they occur in many parts of the world, and the same thing may be true of many of the tardigrades. *Macrobiotus ornatus* (16), which I first found in the Taunus, I met again in moss from St. Gothard, Stowanger, and Spitzbergen, and Schandinn has found it on Bear Island. *M. Sattleri*, another new Taunus species, occurs also in Kerguelen Land. I have seen *Milnesium tardigradum* (13) in moss from Germany, Scandinavia, Spitzbergen, Java, and Kerguelen Land, and in all probability our commonest German bear animalcule, *Macrobiotus Hufelandi*, is equally cosmopolitan. I recently found in Iceland moss the little crab already mentioned. In my examination of the material collected by the German Antarctic expedition I have already established the occurrence in the Antarctic of eight Arctic species of tardigrades, and I was greatly astonished to find again in the Schwarzwald a very curious nematode recently discovered in Kerguelen Land and Possession Island.

The moss dwellers will surely well repay study whether regarded from the viewpoint of biology, of systematic zoology or of the terrestrial distribution of animal forms.—Abstracted for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

FIG. 2.—MOSS INHABITANTS.

1. Amoeba terricola; 2. Arcella vulgaris; 3. Difflugia globulosa; 4. Assulina seminulum; 5. Euglypha spec.; 6. Nebela spec.; 7. Callidina spec.; 8. Nemotodes; 9. Ophiocamptus muscicola; 10. Nothrus horridus; 11. Egg of Cunaxa setirostris; 12. Egg of Bdella arenaria; 13. Milnesium tardigradum; 14. Macrobiotus Hufelandi; 15. Deposit of Macrob. tetradac.; 16. Macrobiotus ornatus tylus; 17. Echiniscus arctomys; 18. Echiniscus quadrispinosus; 19. Egg of Macrob. Hufelandi; 20. Egg of Macrob. echinoge. nitus.

THE EVIDENCE OF EVOLUTION.*

By HUGO DE VRIES.

THE noble aim of university teaching is the lifting up of mankind to a higher appreciation of the ideas of life and truth. It has to cultivate the most intimate connection between theory and practice, between abstract science and actual life. Throughout the world of research this connection is felt to be the real stimulus of the work, the very basis of its existence. American universities and American science have developed themselves on this leading principle, and it is especially on this account that high admiration is given them by their European sisters. Nowhere in this world is the mutual concourse between practice and science so general as here, and nowhere is the influence of universities so widely felt as in this country. Perfect freedom of thought and investigation, unhampered rights of professing and defending one's conviction, even if it should be wholly contrary to the universal belief, are the high privileges of all real universities. Wealthy citizens spend their possessions in the founding of such institutions, convinced that this is the best way of promoting public welfare. The government liberally supplies funds for scientific research whenever its application to practical business is clear. Your system of promoting agriculture by means of experiment stations, of scientifically conducted farm cultures, of inquiries in all parts of the world, and of collecting, introducing, and trying all kinds of plants that might become useful crops is not only admired, but even highly envied by us Europeans.

It is not without hesitation that I have accepted the

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honorable invitation to speak before this renowned center of learning. The ideas to which I have been conducted by my experiments are to a large degree different from current scientific belief. But I have trusted to your willingness to listen to new facts and divergent convictions, and to your readiness to acknowledge whatever spark of truth might be found in them. Unbiased by prejudice, the calm air of the university and the enthusiasm of youth seeking only truth, and convinced that only pure truth can bring real progress, are the judges to which I gladly submit my conceptions.

My ideas have grown slowly, and have only reached their definiteness and full development under the protection of the high principles of university freedom. I have needed nearly twenty years to develop them and to gather the evidence by means of which I hope to convince you. I kept my secret until some years ago, and worked only for myself. In this respect old universities, as ours are in Europe, have a distinct advantage over your young American institutions. With you all is sparkling and boiling, with us it is the quietness of solitude, even in the midst of a busy city. But your students and teachers are expected to show what they are doing, and to produce their results at short intervals. In Europe, on the contrary, we are trusted and left free even on this point. Hardly anybody has ever asked me what I was doing, and even those who from time to time visited my garden were content with what I could show them, without telling my real difficulties and my real hopes.

To my mind this is a high privilege. The solution of the most intricate problems often does not require vast laboratory equipment, but it always requires patience and perseverance. Patience and perseverance in their turn require freedom from all pressure, and especially from the need of publishing early and often unripe results. Even now I would prefer to spend this hour in recounting the obligations which the doctrine of evolution is under to such men as Lamarck and Darwin. I should like to point out how they have freed inquiry from prejudice and drawn the limits between religion and science; how they have caused the principle of evolution to be the ruling idea in the whole dominion of the study of the organic world, and how this idea has been suggestive and successful, comprehensive and hopeful during a whole century of continuous research. Everywhere it is recognized to take the leadership. It has been the means of innumerable discoveries, and whole sciences have been started from it. Embryology and ontogeny, phylogeny, and the new conceptions of taxonomy, paleontology of plants and of animals, sociology, history, and medicine, and even the life history of the earth on which we live, are in reality in their present form the products of the idea of evolution.

Instead of telling you of my own work, I should like to sketch the part which of late the scientists of the United States have taken in this work. Mainly in two lines a rapid advancement has been inaugurated in this country. I refer to the pure university studies and the work of the agricultural stations. Highly valuable is the application of science to agriculture in the improvement of races. Each of you knows how this artificial production of races of animals and plants was one of the great sources of evidence on which Darwin founded his theory. But at this time the available evidence was only very scanty when we compare it with the numerous facts and the improved methods which now are the result of half a century's additional work. America and Europe have combined in this line, and the vast amount of facts, heaped up by numerous investigators and numerous well-equipped institutions, has produced quite a new basis for a critical review of Darwin's theory.

I have tried to combine all these too dispersed facts and to bring them together, in order to obtain a fuller proof for the main points of Darwin's conception. In one subordinate point my results have been different from those of Darwin, and it is this point which I have been invited by the kindness of your president to discuss before you.

Darwin's theory is commonly indicated as the theory of natural selection. This theory is not the theory of descent. The idea of descent with modification, which now is the basis of all evolutionary science, is quite independent of the question how in the single instances the change of one species into another has actually taken place. The theory of descent remains unshaken even if our conception concerning the mode of descent should prove to be in need of revision.

Such a revision seems now to be unavoidable. In Darwin's time little was known concerning the process of variability. It was impossible to make the necessary distinctions. His genius recognized two contrasting elements—one of them he called sports, since they came rarely, unexpectedly, and suddenly; the other he designated as individual differences, conveying thereby the notion of their presence in all individuals and at all times, but in variable degrees.

Sports are accidental changes, resulting from unknown causes. In agricultural and horticultural practice they play a large part, and whenever they occur in a useful direction they are singled out by breeders and become the sources of new races and new varieties. Individual differences are always present, no two persons being exactly alike. In the same way the shepherd recognizes all his sheep by distinct marks, and to find two ears in a field of wheat which cannot be distinguished from one another by some peculiarity is a proposition which everybody knows to be impossible. Many highly improved races of forage plants and agricultural crops have been produced by intelligent breeders simply on the ground of these always available dissimilarities. They can be selected and accumulated, augmented and heaped up, until the new race is distinctly preferable to the original strain.

In ordinary agricultural breeding, however, it is very difficult to distinguish sharply between these two principles. Moreover, for practical purposes, this distinction has no definite use. The practice of selection is nearly the same in both cases, and, besides hybridizing, with which we are not now concerned, selection is as yet practically the only means for the breeder to improve his races. Hence it came that at Darwin's time there was no clear distinction between the two types of variations, at least not to such an extent that a theory of the origin of species could confidently rely upon it.

Quetelet's celebrated law of variability was published only some years after the appearance of Darwin's "Origin of Species." Variability seemed until then to be free from laws, and nearly everything could be ascribed to it or explained by it. But the renowned Belgian scientist showed that it obeys laws exactly in the same way as the remainder of the phenomena of nature. The law which rules it is the law of probability, and according to this law the occurrence of variations, their frequency, and their degree of deviation can be calculated and predicted with the same certainty as the chance of death, of murders, of fires, and of all those broad phenomena with which the science of sociology and the practice of insurance are concerned.

The calculations of probable variations based on this most important law did not, however, respond to the demands of evolution. Specific characters are usually sharply defined against one another. They are new and separate units more often than different degrees of the same qualities. Only with such, however, Quetelet's law is concerned. It explains the degrees, but not the origin, or new peculiarities. Moreover, the degrees of deviation are subject to reversion to mediocrity, always more or less returning in the progeny to the previous state. Species, on the contrary, are usually constant and do not commonly or readily revert into one another. It is assumed that from time to time specific reversions occur, but they are too rare to be comparable with the phenomena which are ruled by the law of probability.

A thorough study of Quetelet's law would no doubt at once have revealed the weak point in Darwin's conception of the process of evolution. But it was published as part of a larger inquiry in the department of anthropology, and for years and years it has been prominent in that science, without, however, being applied to the corresponding phenomena of the life of animals and of plants. Only of late has it freed itself from its bounds, transgressed the old narrow limits, and displayed its prominent and universal importance as one of the fundamental laws of living nature.

In doing so, however, it has become the starting point for a critical review of the very basis of Darwin's conception of the part played by natural selection. It at once became clear that the phenomena which are ruled by this law, and which are bound to such narrow limits, cannot be a basis for the explanation of the origin of the species. It rules quantities and degrees of qualities, but not the qualities themselves.

Species, however, are not in the main distinguished from their allies by quantities nor by degrees; the very qualities may differ. The higher animals and plants are not only taller and heavier than their long-forgotten unicellular forefathers; they surpass them in large numbers of special characters, which must have been acquired by their ancestors in the lapse of time. How such characters have been brought about is the real question with which the theory of evolution is concerned. Now, if they cannot be explained by the slow and gradual accumulation of individual variations, evidently the second alternative of Darwin's original proposition remains. This was based on the sports, on those rare and sudden changes which from time to time are seen to occur among cultivated plants, and which in these cases give rise to new strains. If such strains can be proved to offer a better analogy to real systematic species, and if the sudden changes can be shown to occur in nature as well as they are known to occur in the cultivated condition, then in truth Darwinism can afford to lose the individual variations as a basis. Then there will be two vast dominions of variability, sharply limited and sharply contrasted with one another. One of them will be ruled by Quetelet's law of probability and by the unavoidable and continuous occurrence of reversions. It will reign supreme in the sciences of anthropology and sociology. Outside of these, the other will become a new domain of investigation, and will ask to be designated by a new name. Fortunately, however, a real new designation is not required, since previous to Darwin's writings the same questions were largely discussed and since in these discussions a distinct name for the sudden and accidental changes of species into one another was regularly used. At that time they were called "mutations," and the phenomenon of mutability was more or less clearly distinguished from that of variability in a more limited sense. Especially in France a serious scientific conflict raged on this point about the middle of the last century, and its near relation to religious questions secured it a large interest. Jordon and Godron were the leaders, and numerous distinguished botanists and zoologists enrolled themselves under their banners. They cleared part of the way for Darwin and collected a large amount of valuable evidence. Their facts pleaded for the sharp and abrupt delimitation of their species, and asked for another explanation than that which was derived from the ordinary, slow, and continuous variations.

Their evidence, however, was not complete enough to command the decision in their behalf. The direct proof of the sudden changes could not be offered by them, and they allowed themselves to be driven to the acceptance of supernatural causes on this account. Thereby, however, they lost their influence upon the progress of science, and soon fell into oblivion.

Instead of following this historical line, however, I have now to point out one of the weightiest objections against the conception of the origin of species by means of slow and gradual changes. It is an objection which has been brought forward against Darwin from the very beginning, which has never relented, and which often has threatened to impair the whole theory of descent. It is the incompatibility of the results concerning the age of life on this earth, as propounded by physicists and astronomers, with the demand made by the theory of descent.

The deductions made by Lord Kelvin and others from the central heat of the earth, from the rate of the production of the calcareous deposits, from the increase of the amount of salt in the water of the seas, and from various other sources, indicate an age for the inhabitable surface of the earth of some millions of years only. The most probable estimates lie between twenty and forty millions of years. The evolutionists of the gradual line, however, had supposed many thousands of millions of years to be the smallest amount that would account for the whole range of evolution, from the very first beginning until the appearance of mankind.

This large discrepancy has always been a source of doubt and a weapon in the hands of the opponents of the evolutionary idea, and it is especially in this country that much good work has been done to overcome this difficulty. The theory of descent had to be remolded. On this point conviction has grown in America during the last decades with increasing rapidity. Cope's works stand prominent among all, and much valuable discussion and evidence has been brought together.

The decision, however, could only be gained by a direct study of the supposed mutations, but no distinct cases of mutability were at hand to provide the material. Discussions took the place of inquiry, and a vast amount of literature has broadly pictured all the possibilities and all the more or less plausible explanations without being able to give proof or disproof.

In this most discouraging state of things I concluded that the only way to get out of the prevailing confusion was to return to the method of direct experimental inquiry. Slow and gradual changes were accepted to be invisible or nearly so; mutations, however, would be clear and sharp, although of rare occurrence. I determined to start on a search for them, and tried a large number of species, partly native forms of my own country and partly from different sources. Each of them had to be tried as to its constancy, and large numbers of seedlings had to be produced and compared. The chance of finding what I wanted was of course very small, and consequently the number of the experiments had to be increased as far as possible.

Fortune has been propitious to me. It has brought into my garden a series of mutations of the same kind as those which are known to occur in horticulture, and moreover it has afforded me an instance of mutability such as would be supposed to occur in nature. The sudden changes, which until yet were limited to the experience of the breeders, proved to be accessible to direct experimental work. They cannot yet in truth be produced artificially, but, on the other hand, their occurrence can be predicted in some cases with enough probability to justify the trial. Color changes in flowers, double flowers, regular forms from labiate types, and others have been produced more or less at will in my garden, and under conditions which allowed of a close scientific study. The suddenness of the changes and the perfection of the display of the new characters from the very beginning were the most striking results.

These facts, however, only gave an experimental proof of phenomena which were historically known to occur in horticulture. They threw light upon the way in which cultivated plants usually produce new forms, but between them and the real origin of species in nature the old gap evidently remained.

This gap, however, had to be filled out. Darwin's theory had concluded with an analogy, and this analogy had to be replaced by direct observation.

Success has attended my efforts even on this point. It has brought into my hands a species which has been taken in the very act of producing new forms. This species has now been observed in its wild locality during eighteen years, and it has steadily continued to repeat the phenomenon. I have brought it into my garden, and here, under my very eyes, the production of new species has been going on, rather increasing in rate than diminishing. At once it rendered superfluous all considerations and all more or less fantastical explanations, replacing them by simple fact. It opened the way for further investigations, giving nearly certainty of a future discovery of analogous processes. Whether it is the type of the production of species in nature or only one of a more or less large group of types cannot yet be decided, but this is of no importance in the present state of the subject. The fact is that it has become possible to see species originate, and that this origin is sudden and obeys distinct laws.

The species which yielded these important results is an American plant. It is a native of the United States, and nearly allied to some of the most common and most beautiful among the wild flowering plants of

this country. It is an evening primrose, and by a strange but fortunate coincidence bears the name of the great French founder of the theory of evolution. It is called "Lamarck's evening primrose," and produces crowns of large and bright yellow flowers, which have even secured it a place among our beloved garden plants.

The most interesting result which the observation and culture of this plant have brought to light is a fact which is in direct opposition to the current belief. Ordinarily it is assumed that new species arise by a series of changes, in which all the individuals of a locality are equally concerned. The whole group is supposed to be modified in a distinct direction by the agency of the environmental forces. All individuals from time to time intercross, and are thereby assumed to keep equal pace in the line of modification, no single one being allowed to go distinctly ahead of the others. The whole family gradually changes, and the consequence would be that the old form disappears in the same degree as the new makes its appearance.

This easy and plausible conception, however, is plainly contradicted by the new facts. There is neither a gradual modification nor a common change of all the individuals. On the contrary, the main group remains wholly unaffected by the production of new species. After eighteen years it is absolutely the same as at the beginning, and even the same as is found elsewhere in localities where no mutability has been observed. It neither disappears nor dies out, nor is it ever diminished or changed in the slightest degree.

Moreover, according to the current conception, a changing species would commonly be modified into only one other form, or at best become split into two different types, separated from one another by flowering at different seasons or by some other evident means of isolation. My evening primrose, however, produces in the same locality, and at the same time, from the same group of plants, quite a number of new forms, diverging from their prototype in different directions.

Thence we must conclude that new species are produced sideways by other forms, and that this change only affects the product, and not the producer. The same original form can in this way give birth to numerous others, and this single fact at once gives an explanation of all those cases in which species comprise numbers of subspecies, or genera large series of nearly allied forms. Numerous other distinct features of our prevailing classification may find on the same ground an easy and quite natural explanation.

To my mind, however, the real significance of the new facts is not to be found in the substitution of a new conception for the now prevailing ideas; it lies in the new ways which it opens for scientific research. The origin of species is no longer to be considered as something beyond our experience. It reaches within the limits of direct observation and experiment. Its only real difficulty is the rarity of its occurrence; but this, of course, may be overcome by persevering research. Mutability is manifestly an exceptional state of things if compared with the ordinary constancy. But it must occur in nature here and there, and probably even in our immediate vicinity. It has only to be sought for, and as soon as this is done on a sufficiently large scale the study of the origin of species will become an experimental science.

New lines of work and new prospects will then be opened, and the application of new discoveries and new laws on forage crops and industrial plants will largely reward the patience and perseverance required by the present initial scientific studies.

ENGINEERING NOTES.

A horizontal grate with intermediate shell, in which the fuel is supplied to the grate from the side by means of a contrivance admitting of regulation, has been considered deserving of a patent by the Imperial German Patent Office. The movement of the shutting-off slide for the pipes of the intermediate shell entering the furnace from the side is dependent on the opening and closing of the fire-door, as well as on opening and shutting off the air supply under the grate. Accordingly, the opening of the furnace door for removing the slags from the furnace and stoking the fire cannot take place before the shut-offs for the supply of coal and air are closed. The last-named slides of the horizontal grate in question, invented by Friedrich Steinberg, of Schlüsselburg near St. Petersburg, are connected for the purpose of combined movement, and a shutter for the furnace door has been inserted in the connection in such a manner that the furnace door is only released when the slides are closed.—Technische Berichte.

The multiple-stage centrifugal pump offers a practical solution for pumping impure liquids to great heights or against great pressures, easily and economically, as in mines for pumping water containing all kinds of foreign materials for fire pumps to maintain a sufficient number of fire streams indefinitely. Also certain combinations of multiple-stage pumps can be readily made to pump a quantity of water to a certain height to start a barometric condenser and then twice the quantity to one-half the original height after the siphon action of condenser is established to maintain the necessary vacuum at a constant speed of pump. Other adaptations allow of maintaining a variation of pressures on hydraulic elevators at a constant speed of pump to vary the speed of elevators to accommodate variations in the demands for service during the different hours of a day; or discharging under several different pressures for varying services or to varying heights for similar purposes. In fact the variations to be obtained by this class of pump seem to be indefinite and only limited by the demands for service and the ingenuity of the designer in making combinations of the different stages, consequent upon a multiplicity of impellers.

SCIENCE NOTES.

The number of people entering the medical profession is probably too great. In the United States of America, including the Philippines, Porto Rico, and Hawaii, there were in 1901, 115,222 physicians in a population of 84,332,610. The last complete data we have concerning the number of attendants in medical schools are for 1899. In this year there were, excluding graduate schools, 156 medical schools in the United States with 24,119 students. The growth in the number of medical students in twenty-one years has been 142 per cent. In addition to these undergraduate schools there are eight graduate medical schools which had (in 1895) 624 instructors and 1,813 students, of whom 59 were women.

Stimulated by the marked advancement which has been made in physical chemistry, especially in the knowledge of electrolytic dissociation, the past few years have added much to our fund of information with relation to the toxic action upon plants of solutions of both acids and salts, as well also as of certain non-electrolytes. The work of Kahlenberg and True, Heald, Krönig and Paul, Clark, and others has contributed enough data for an appreciation of the limitations of toxic action. Nevertheless no broad generalizations are as yet possible. Indeed, it is not generalizations which are wanted, but further experimental data bearing upon the relation to the toxicity of the ions and molecules and their respective interactions.

It is difficult to imagine any contrivance which human ingenuity could construct better calculated to secure the best conditions for disease and the best methods for propagation thereof than the sleeping car. Constructed in such a way that ventilation is practically impossible; partitioned into small compartments, carefully curtained to prevent any circulation of air, if there should be fresh air; provided with enough heating surface to the cubic yard to complete the installation of a Turkish bath, and manned by porters to whom high temperature is an evidence of heavenly bliss, it is not difficult to conceive of the tortures to which the helpless passenger is exposed. These compartments often carry, without any precautionary inspection, persons in all stages of phthisis and even other contagious diseases. There is no health officer to inspect incoming passengers, no provision of the law requiring complete fumigation and no systematic appliance of any kind to prevent or eradicate disease. It has been claimed that the blankets are *washed at least twice a year*, as if that alone were a sufficient excuse for all of the dangers that exist! Perhaps, if one used the same blanket himself all the time he might not be justified in objecting to such frequent ablutions, but what right have we to ask if such a *careful* purification of a blanket used by a different person every night is based on any of the broad principles of hygiene or good taste?

Many investigators have worked upon the problem of nitrogen fixation, and step by step the important facts have been discovered. The Department of Agriculture has had a hand in the later developments of this work. The physiologists of the department have succeeded in working out the complete life history and habits of the root tubercle bacteria which, living in the roots of legumes, secure nitrogen from the atmosphere, thus enabling these crops to grow luxuriantly in soils devoid of this scarcest and most expensive of all food elements. Soils poor in nitrogen may, by the use of these bacteria and proper legumes, be enriched from the inexhaustible supply of nitrogen in the atmosphere. The nitrogen-fixing power of these bacteria has been increased more than fivefold by cultivation and selection on nitrogen-free media in the laboratory. A cheap and thoroughly effective way of distributing and applying these organisms in general agricultural practice has been devised and put into use on a large scale. At a cost of a few cents a bushel, the seeds of clover, alfalfa, peas, beans, or any other legumes may be inoculated with these bacteria, thus making it possible to secure good crops on soils devoid of nitrogen, and at the same time leave a large quantity of this element fixed in the soil in a form available to wheat, corn, potatoes, or any other crop that may follow the legumes. The bacteria are helped to live and multiply by their host plant, the host in turn is supplied with nitrogenous food by these bacteria, and the host upon dying leaves its decaying roots, leaves, etc., to supply stored-up nitrogen to succeeding crops, or to neighboring plants which may outlive the legume and feed upon its disorganized parts. The value of legumes as restorers of fertility, apart from their value as food, has thus been greatly increased. These crops without the nodule-forming bacteria exhaust the nitrogen of the soil, like any other crop. This investigation, however, does not stop with the nodule-forming organisms. There are other bacteria known which have the power of fixing nitrogen from the atmosphere independently of any particular crop. It may be possible when the life history and habits of these species are fully ascertained to improve, cultivate, and distribute them as we do the tubercle forms. If this can be accomplished they will supplement the work of the tubercle bacteria and will add greatly to the world's supply of stored nitrogen, which is one of its greatest sources of wealth.

ELECTRICAL NOTES.

The phenomena occurring in an electric conductor have long been studied exclusively by the aid of what is called electrical resistance of the conductor. Now in spite of the undoubted usefulness of this method, Ohm's law has lost of late years much of its absolute character and must be considered rather as an interpolation formula of relatively limited range. In a memoir published in the Elektrotechnische Zeitschrift Prof. H. Th. Simon suggests substituting for the above method what he terms characteristics of the conductor, viz., $e = f(i)$; that is to say the relation between the pressure at the terminals e and the current intensity i. This relation would have to be established by experiment in each given case. In the most simple special case, the curve representing this function would be reduced to a straight line, passing through the origin of co-ordinates and having the equation $ir = e$, when the law of Ohm would be used to advantage. After supplementing from various points of view the theory of characteristic curves, the author uses his results to elucidate the behavior of electric arcs. He suggests two methods of ascertaining the dynamic characteristics of the arc, finding by their aid a hysteresis phenomenon in the arc which is the analogue of the well-known phenomenon observed in the case of magnetic circuits. He next establishes and discusses a theory of the electric arc on the ionic theory. This is utilized to account for the experimental results and at the same time permits of explaining rather satisfactorily a number of observations made in the case of alternate current arcs and spark discharges. The phenomenon called delay of discharge and the specific difference observed in the behavior of metallic and carbon arcs respectively are accounted for by merely quantitative differences. The phenomenon of Duddell's singing arc is finally found to be due exclusively to the hysteresis of the arc.

While engaged in an investigation of the behavior of all types of coherers, Mr. G. Ferrié designed a detector of Hertzian waves, depending on the imperfect contact of a metallic point and an electrolyte. This apparatus has been recently studied more closely, and in a memoir before the French Academy of Sciences the author records the following facts. The apparatus consists of a platinum point 0.01 millimeter in diameter, immersed in an electrolyte (nitric or sulphuric acid) to a length of the same order of magnitude as its diameter. This electrolyte communicates by means of a broad electrode with the feeding wire of a telephone, the other terminal of which is connected with the platinum point. On the other hand the electrolyte and platinum point are connected with a circuit, where oscillations of low energy are produced and collected by a receiving antenna, situated at a rather small distance from the antenna transmitting the signals. Under these conditions, each set of waves is found to produce a sound in the telephone, the transmitted signals being read acoustically. It should be observed that no sound is heard if the detector be disconnected or else replaced by a condenser of any desired capacity. If the telephone be replaced by a ballistic galvanometer the energy of the oscillations being sufficiently increased, there will be produced at each set of waves a deflection of the instrument, occurring always in the same direction and corresponding with the same amount of current coming from the platinum point. The detector will in this case work like a valve, any negative impulses passing freely, whereas the positive are stopped by the detector, but are allowed to pass through the circuit of the telephone or galvanometer, acting on these apparatus as they are always of the same direction. The electrolytic condenser constituted by the platinum point and the liquid is charged and to some extent regulates the above phenomena. On the other hand an appreciable interval is found to elapse between the moment the apparatus is subjected to the action of the oscillations and the instant the sound is perceived in the telephone, this interval being required to produce the polarization of the imperfect contact. The sensitiveness of the apparatus is greatly increased by inserting in the telephone circuit an electromotive force, so that the positive terminal is connected to the platinum point. The sensitiveness will augment with the electromotive force, provided the latter be below a given limit, viz., the pressure required for the electrolysis of the liquid. If the telephone be replaced by a ballistic galvanometer and if the energy of the oscillations be augmented sufficiently, each set of waves will be found to result in a deflection of the instrument of opposite direction to that observed in the case of a circuit devoid of any electromotive force. The phenomenon is thus distinctly different. The following explanation is offered, the valve effect becoming negligible: At the state of rest, the electromotive force inserted in the circuit will result in the production of counter electromotive force of polarization, the instrument being traversed only by the spontaneous depolarization current. The contact of the platinum point and the liquid will thus constitute an electrolytical condenser, charged to the tension of the electromotive force, while the dielectric is formed by a thin gaseous membrane. The oscillations will result in the discharge of this condenser producing a temporary conductivity of the dielectric analogous to the one observed in the case of self-decohering coherers. As soon as the oscillations have ceased, the conductivity will be found also to be discontinued, the condenser being recharged. The charge current existing at this moment will be perceived in the telephone or ballistic galvanometer, its intensity depending on the amount of discharge.

TRADE NOTES AND RECIPES.

Substitute for Lycopodium.—Messrs. Kalb and Helbig have introduced in Germany a substitute for lycopodium. In a volatile mineral or vegetable liquid, such as benzine, petroleum, chloroform, ether, or alcohol, are dissolved vegetable, animal, or mineral oils. The mixture is shaken smartly to render it milky. A soft, fatty, comminuted mass, as of chalk, kaolin, gypsum, magnesia, or talc, is introduced into the mixture, forming a kind of pulp, which is filtered, dried, and screened. The product is said to have all the qualities of lycopodium, without being so costly, and consequently not requiring so much economy in its employment in metallurgy.

The "Argento-Nickel" Process.—The pieces are first nickeled according to ordinary processes, except that the bath of 3,000 liters used for this work should contain 80 per cent of nickel sulphate, single, 20 per cent of double nickel sulphate, and 10 kilogrammes of boracic acid per 100 kilogrammes of nickel sulphate. For proper adherence, this first operation should continue for an hour. Then, by means of a commutator, the electric current, which has been directed on the rods supporting the anodes of nickel, is interrupted, and directed on new rods supporting anodes of platinum. This second operation should last about fifteen minutes. The two operations should take place without taking the pieces from the bath. These are the directions of M. Bourel, the French patentee.

Production of Bronze or Metallic Powders.—M. Baer has patented in France a process by which the metal or alloy is converted during its passage from the liquid to the solid state into thin leaves, which are afterward reduced to powder by beating, grinding or other means. The melted metal is run in the form of a sheet or rain into a chamber, which may be a sheet iron box or cylinder, in which a shaft with attached paddles is made to turn rapidly. A violent movement of the air is thus produced, and the falling metal is converted into thin leaves by the time it reaches the solid state. If in the form of drops, the paddles beat it into leaves. The opening by which the metal is introduced may be a slot, which will facilitate the forming of leaves. The process may also be conducted by compressing the air in an inclosure and injecting it into a receiver having fixed or movable pieces attached to the walls. The violent current of air will force the falling metal against these pieces and produce the result previously stated. To avoid the oxidizing action of the air, neutral gases may be utilized, such as a mixture of nitrogen and carbonic acid produced by combustion.

Purification of Arseniated Gases.—The large German establishment, the Badische Anilin und Soda Fabrik, has taken out a patent for the purification of these gases, based on the faculty of certain substances to retain not only dust, but the vapors of arsenic contained in hot gases. These are principally clay, infusory earths, pumice stone, coke, broken fire brick, blast furnace slag, the alkaline and earthy alkaline sulphates and phosphates, as well as those of magnesium, aluminium, and of the heavy metals. The filtering power of these substances is singularly intensified at a high temperature. Thus, for clay, it is said that the power has been multiplied twenty and thirty times when its temperature has been raised to 350 deg. and 400 deg. C. The oxides of iron, copper, chromium, and manganese can be advantageously employed, either alone or in mixture. These will retain the impurities of arsenic at a comparatively low temperature, well below the dark red; that is, at a degree where catalytic effects are not perceived. This is the great advantage of the process, that the filtration of the gases is attended with no appreciable catalytic effect, and that thus the percentage of sulphurous acid is not modified. In this way, the conversion into sulphuric acid can be accomplished in a single operation. It is evident that the process designed in the first instance for the purification of the gases for catalytic purposes, can be applied to other chemical industries.

Production of Anhydrous Alumina.—All the anhydrous alumina of commerce is procured by the treatment of bauxite with alkali, followed by the calcination of the hydrate. But the process cannot be employed with clays, kaolins or silicious bauxites. But by the process now to be operated it is possible to separate the alumina from any of these substances. The reversible reaction indicated by the equation $Al_2O_3 + 6HF = Al_2F_6 + 3H_2O$, is the foundation of the process, fluorhydric acid being employed as an intermediary, and caused to act several times for the conversion of new quantities of alumina into fluoride, and for the production of fluorhydric acid and alumina, when this fluoride is attacked by superheated steam. First, fluoride of alumina is prepared from clay, kaolin, bauxite or other suitable aluminous substance, and an acid containing fluorine, which may be fluorhydric acid or hydrofluosilicic acid, and generally it is rendered porous. This fluoride is then placed in a retort or suitable oven and exposed to the action of superheated steam. Fluorhydric acid is disengaged and conducted by a conduit to a leaden receiver, where it is condensed. The residue usually remains in the retort until the disengagement of the acid is complete, though, if desired, it can be taken from the retort previously. This residue is alumina. The percentage of fluorhydric acid depends on the quantity of steam employed, but it can be produced in sufficient proportion to serve directly for the production of a new quantity of fluoride. The yield of fluorhydric acid from the fluoride corresponds to the theory.—Rev. des Produits Chimiques.

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